POWER

Vol. 40 NEW YORK, AUGUST 4, 1914 No. 5

[Suggested by George B. Longstreet, Somerville, Mass.]

Safety First

Gadsden Steam Power Plant, Gadsden, Ala.

By Warren O. Rogers

SYNOPSIS—A standby steam-power station of 10,000-kw. capacity. A feature of interest is the condenser pit, 38 ft. deep, 27½ ft. wide and 66½ ft. long, containing two 6000-sq.ft. surface condensers, two turbine-driven circulating pumps and two house pumps. Placing the main smoke flue on the power-house roof is an innovation from ordinary practice, as is the outdoor substation.

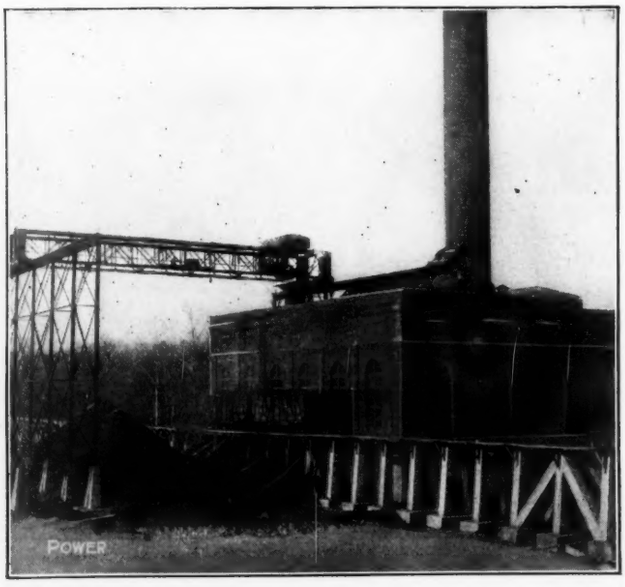


Fig. 1. Coal-Handling Apparatus and Smoke Flue on the Roof

The Alabama Power Co., Birmingham, Ala., recently completed and put into operation a steam-turbo-generator station of 10,000-kw. capacity at Gadsden, Ala. The company is also building, a water-power development at Lock 12, on the Coosa River, which will have a rating of 54,000 kv.a., and it has plans for constructing a high-tension transmission system which, when completed, will extend over a network of more than 800 miles, reaching to the most important parts of the state. The Gadsden steam plant, which cost about $800,000, and the Coosa River development have a total of 65,000 kv.a. for present distribution.

The steam plant is situated close to the Coosa River, about two miles from Gadsden. The building, Fig. 1, has a concrete substructure and a brick and steel superstructure.

Turbine Room

In the turbine room, there are two six-stage, 5000-kw. horizontal turbo-generators, Fig. 2. The operating floor is divided by a 13-in. thick curtain wall separating the turbine room from the pump and boiler room. Fig. 3, a plan view of the plant, shows the general arrangement of the units. The turbine room is 91 ft. 4 in. long by 50 ft.

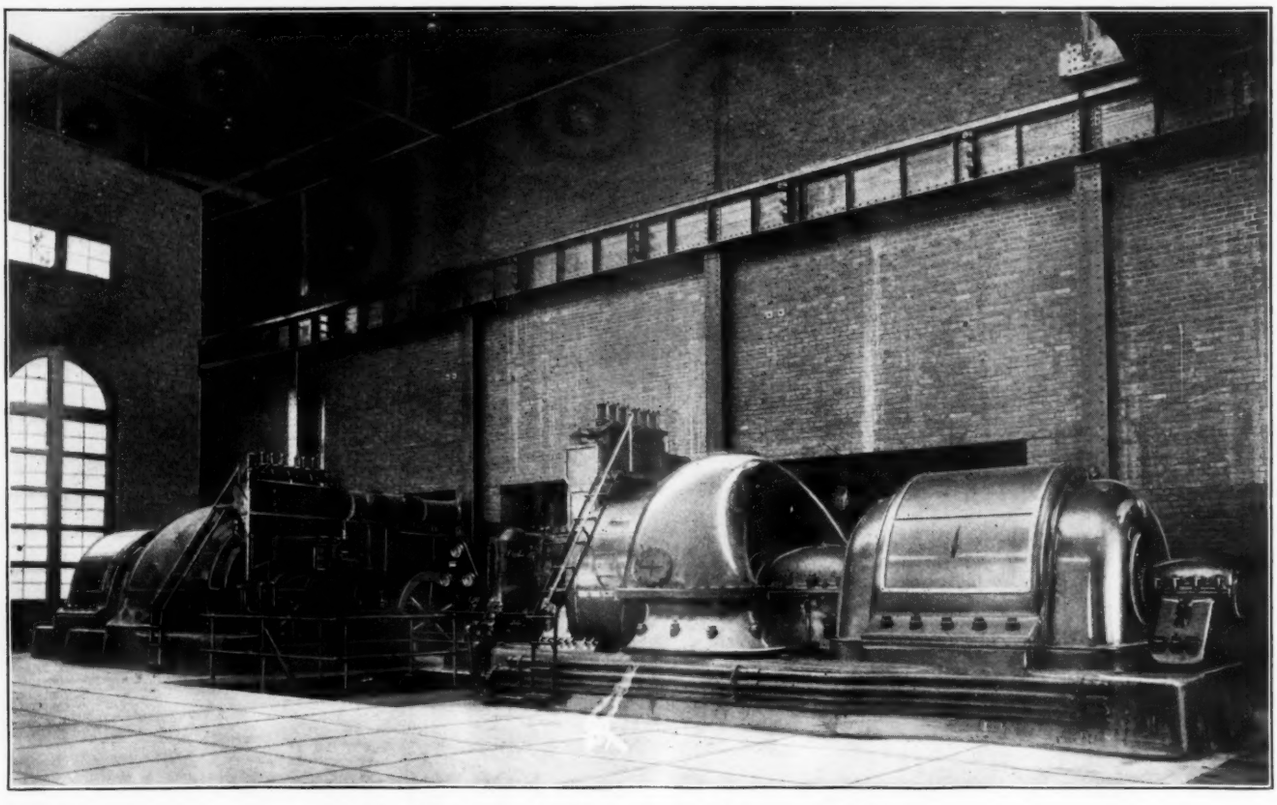


Fig. 2. Two 5000-Kw. Turbo-Generator Units

wide. The turbines are next to the curtain wall, leaving ample room for two more units of the same floor area.

Of the two exciter units, each of 100-kw. capacity, one is driven by a 150-hp. induction motor at 880 r.p.m., and the other by a 100-kw. steam turbine at 2400 r.p.m. Both direct-current generators supply energy at 125 volts. The motor-driven unit is near the switchboard, but the other way, are two turbine-driven, 24-in. tri-rotary pumps, which at 900 r.p.m. supply circulating water to the condensers. Two 10- and 10 by 10-in. service pumps supply water to the tank on the power-house roof. There are also two turbine-driven hotwell, 4-in. turbine pumps.

Fig. 5 shows the arrangement of apparatus in the condenser pit. Condensers are placed in the pit under each

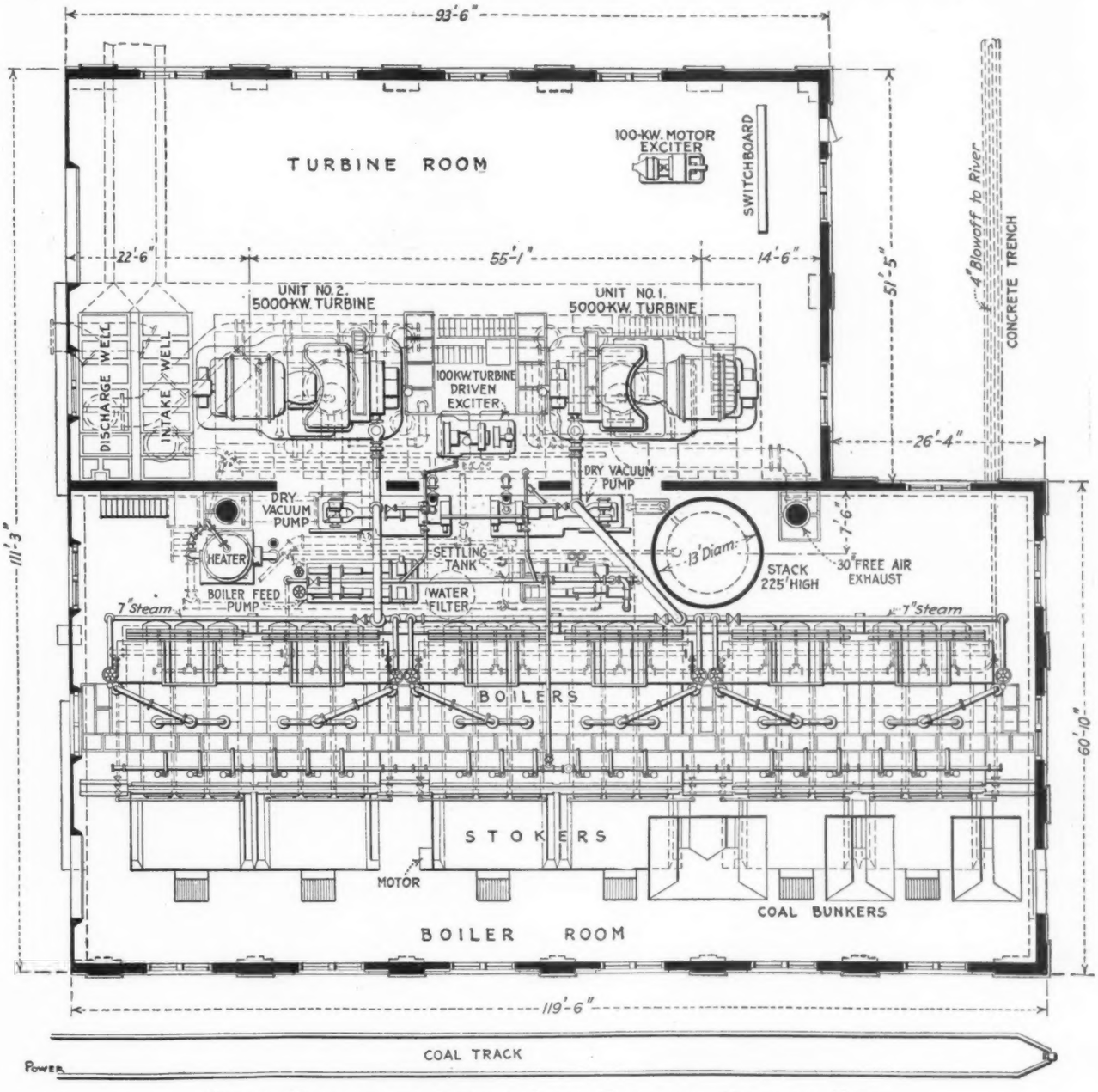


FIG. 3. PLAN OF THE GADSDEN POWER PLANT AND PRINCIPAL PIPING

is between the two main turbines and back of the condenser pit, Fig. 4.

CONDENSERS

Each of the two condensers has 14,000 sq.ft. of cooling surface, a total of 28,000, or 2.8 sq.ft. per generator kilowatt. They rest on I-beams set in the concrete walls of the condenser pit, which is 27½ ft. wide, 66½ ft. long and 38 ft. deep. The walls and bottom of the pit are 4 ft. thick. At the bottom, which is reached by an iron stair-

turbine and piped to it by a 6-ft. diameter exhaust connection. The circulating water is pumped from the river to the condensers through an intake tunnel on the suction side of the circulating pump and a 30-in. discharge pipe to the condenser, at the side near the top. The discharge water flows back to the river by gravity.

Condensate from the condensers is pumped from the hotwell to a vacuum heater just back of the boilers at one end of the pump room. When there is more hot water than can be handled through the heater, which occurs

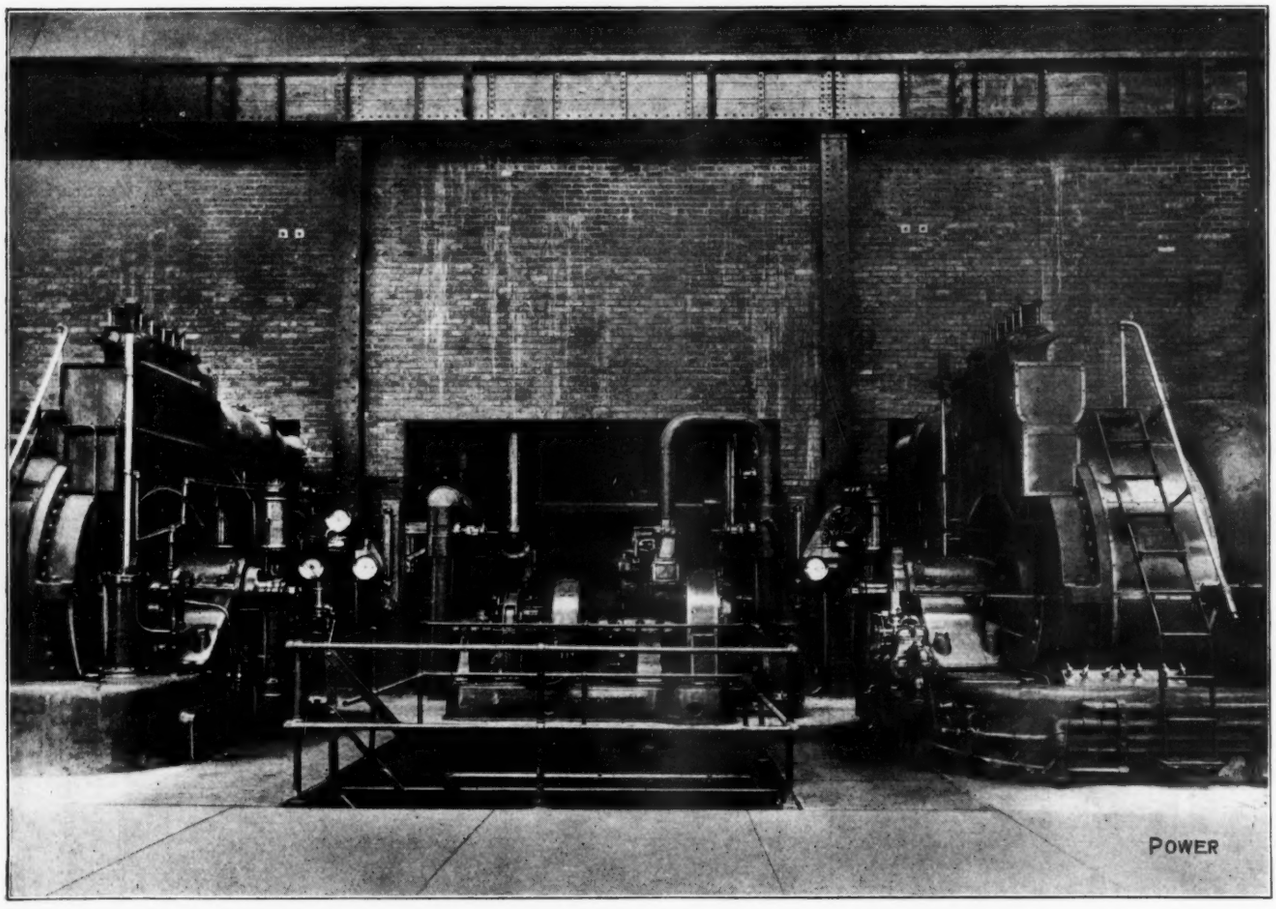


FIG. 4. CURTAIN WALL, CONDENSER PIT AND TURBINE-DRIVEN EXCITER UNIT

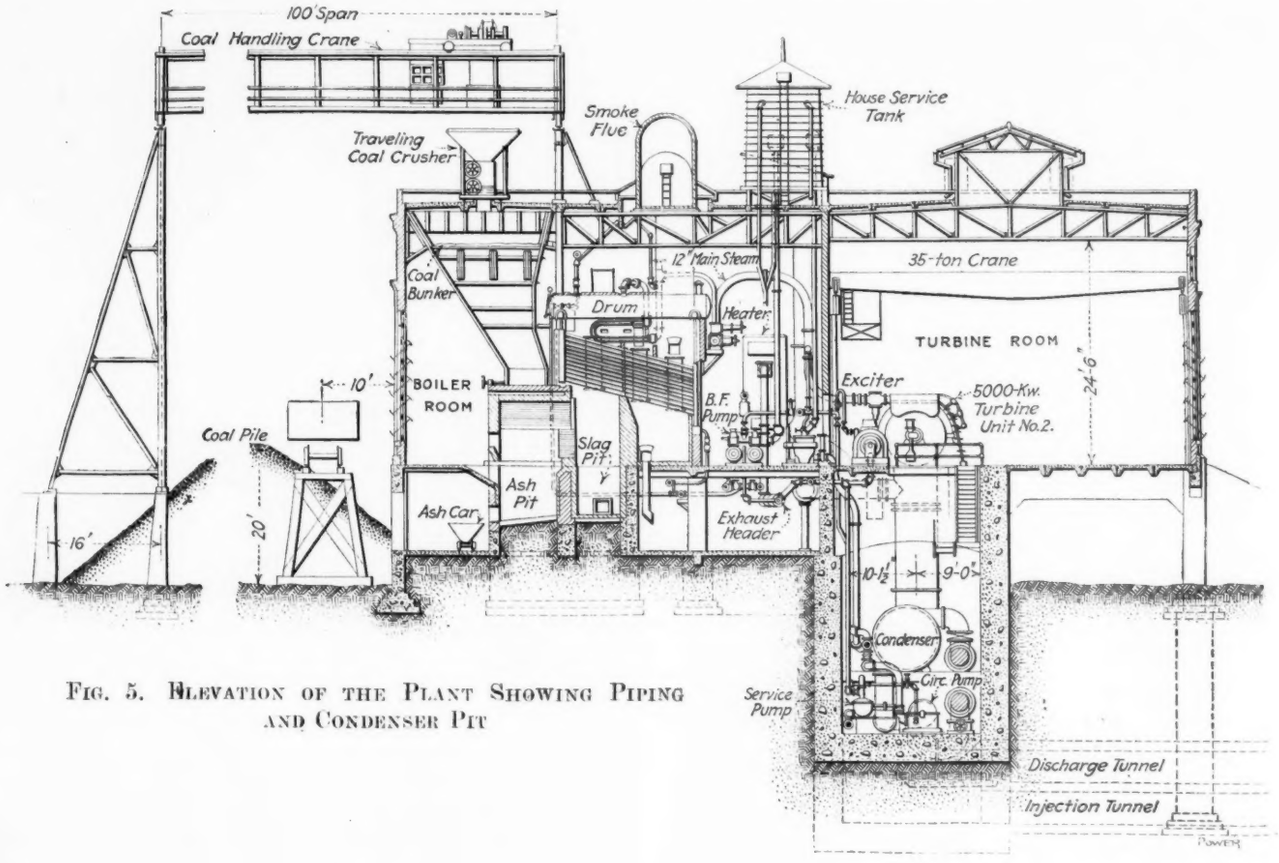


FIG. 5. ELEVATION OF THE PLANT SHOWING PIPING AND CONDENSER PIT

at certain times when there is a minimum demand for feed water by the boilers, the excess water goes to a hot-water storage tank. When the heater is working at its maximum capacity, any increase in the feed-water supply causes a float valve to open and the excess water goes to a storage tank. As the demand for feed water increases and the water in the heater falls below a predetermined level, a float valve is opened on a line between the storage tank and the condensers, allowing the hot water to return to the condensers; it is then fed from the hotwell to the heater. By this arrangement, there is no waste of feed water and hot water is always available for maximum demands. Makeup water is obtained from the house tank and the supply is automatically controlled. This water is taken from the river and passes through filters before going to the tank.

Between the vacuum heater and the chimney are two 10- and 25- by 18-in. dry-vacuum pumps and two 18- and 10- by 18-in. outside, center-packed, boiler-feed pumps, Fig. 6. Each air pump is connected to a condenser by a 12-in. pipe. The exhaust pipe from the steam end connects with a common auxiliary 12-in. exhaust line running to the heater. The steam lines to the air pumps are 6 in. in diameter, and branch from a main 6-in. auxiliary header; the dry-air pumps also receive steam from the 6-in. header. All auxiliary exhausts are piped to a common main equipped with an 8-in. atmospheric exhaust. The turbines have a free air exhaust 30 in. in diameter.

There are six three-drum, 600-hp. water-tube boilers, Fig. 7, each with 294 four-inch tubes, 18 ft. long and placed 21 wide and 14 high. The boilers are designed for 225 lb. pressure, but only 185 lb. is carried.

The dutch-oven furnaces are equipped with automatic stokers, having a grate 12 ft. wide and 8 ft. 7 in. long, or 103 sq.ft. of surface. As each boiler has 6000 sq.ft. of heating surface, the ratio to the grate area is 58.25 to 1. The top of the furnace is 10 ft. 10½ in. above the fire-room floor, which gives an interior furnace height of 8 ft. 3 in. above the bottom of the stoker. This construction calls for a bridge-wall 9 ft. 3 in. high, with a 6-ft. space between it and the inner end of the furnace.

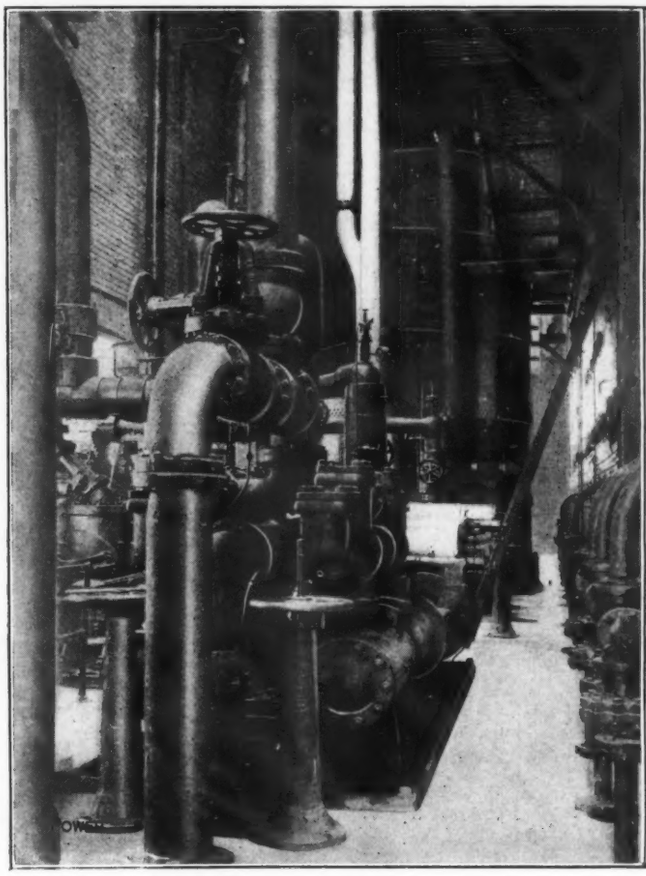


FIG. 6. BOILER-FEED PUMPS AND REAR END OF BOILERS

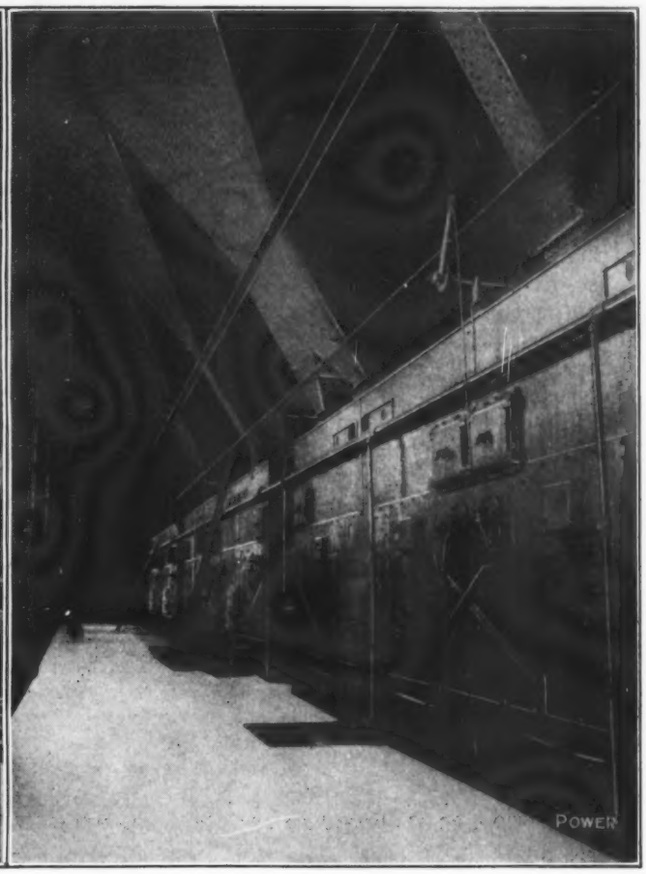


FIG. 7. PARTIAL VIEW OF THE BOILER ROOM AND COAL BUNKERS

The 5x6-ft. smoke uptakes are at the back end of and above the boilers, each having an area of 30 sq.ft. These connect with a main smoke flue on the roof, as shown in Fig. 8. The flue is constructed of sheet steel lined with firebrick, is 12 ft. 5 in. high at the center section and 7 ft. 9 in. high at both ends, with a cross-section of 7 ft. 3 in. The outlet connects with a brick-lined steel chimney having an inside diameter of 13 ft. It is 225 ft. high above the boiler-room floor, and has a stack area of 132.73 sq.ft., or 22.12 sq.ft. per boiler. Its sectional area bears a ratio to the grate of 1 to 1.29 sq.ft. As there are 10,000-kw. capacity in turbines and 3600 hp. in boilers, there is one horsepower for each 2.77 kw. in output.

Of the several advantages in placing the smoke flue where it is, more room is had above or at the rear of the boilers, it is out of the way of piping and, although

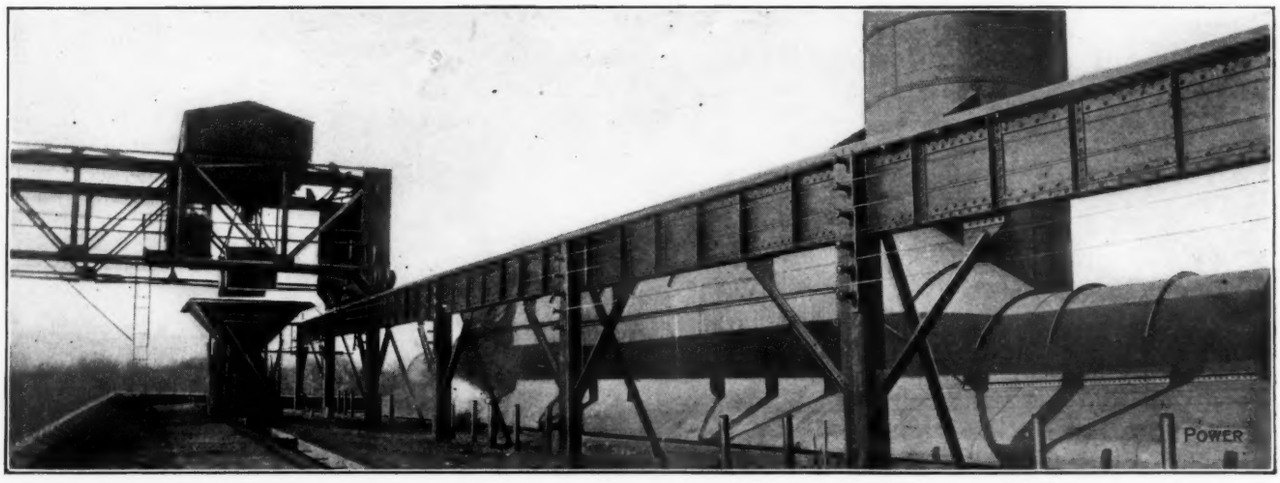


FIG. 8. LINED METAL SMOKE FLUE ON ROOF OF THE BOILER HOUSE, TRAVELING CRANE AND COAL CRUSHER

exposed to the elements the year round, this is not necessarily disadvantageous, because of the mild climate; and, being lined, the coolest weather reduces the temperature of the gases but slightly.

At the right of Fig. 8 is shown the traveling crane, which has a span of 110 ft., and the grab bucket of 2¼-tons capacity. Coal is delivered in railroad cars and dumped from the trestle, Fig. 1, into a yard with a storage capacity of 9000 tons. The grab bucket dumps the coal into an electrically controlled traveling coal crusher, which runs on rails on each side of the opening above the six coal hoppers. After crushing, the coal falls into the hoppers and is then discharged by gravity to the stokers.

The boilers are arranged in three pairs so that either set can supply steam to either turbine; in fact, the plant is laid out on the unit system.

At the rear of the boilers is the 7-in. main steam header, approximately 5 ft. below the center line of the steam drums. Saturated steam is taken from the three drums on each boiler to the superheater connection through a 7-in. pipe, the outlet pipe to the header being of the same size. A stop valve in the main header between each set of two boilers permits of cutting them out without interfering with the operation of the remaining boilers.

Above the two feed pumps is a 7-in. feed main from which two duplicate feed lines run to two 7-in. pipes, connecting two header lines of the same size, thus giving two sources of boiler feeding from either pump.

The generators are wound for 2300 volts and the voltage is stepped up by two banks of three winding transformers to either 22,000 volts for local transmission or

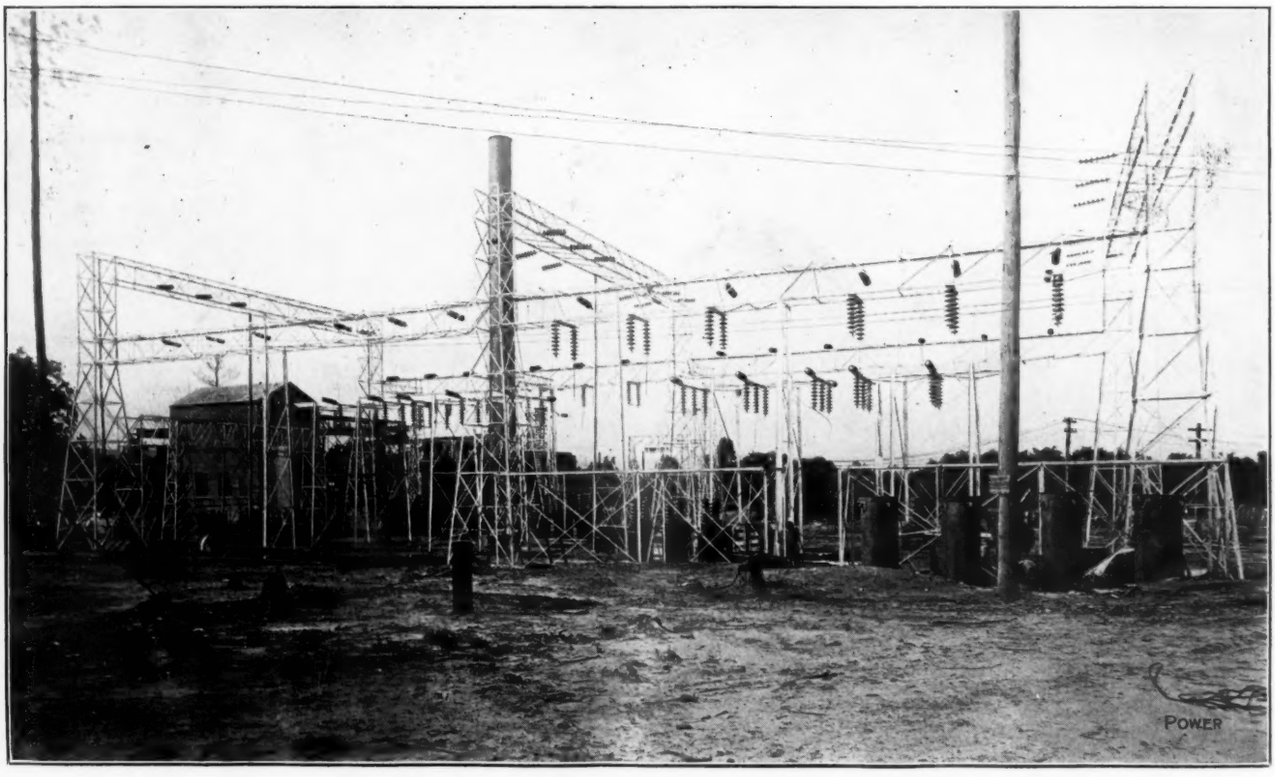


FIG. 9. OUTDOOR SUBSTATION AT THE GADSDEN PLANT

PRINCIPAL EQUIPMENT OF THE GADSDEN STEAM POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Steam, horizontal.	5000 kw	Main units	1800 r.p.m., condensing 185 lbs. steam	General Electric Co.
2	Generators	Alt. current	5000 kw	Main units	1800 r.p.m. 2300 v., 1570 amp., 3 phase 60 cycle	General Electric Co.
1	Turbine	Steam	100 kw	Driving exciter	2400 r.p.m. 185 lb. non-condensing	General Electric Co.
1	Motor	Induction	150 hp	Driving exciter	880 r.p.m. 2200 v., 3 phase, 60 cycle	General Electric Co.
2	Generators	Direct current	100 kw	Exciter	800-2400 r.p.m., 125 volt, 800 amp	General Electric Co.
2	Condensers	Surface	14,000 sq.ft.	With main units	28 to 29 in. vacuum	Henry R. Worthington
2	Turbines	Steam, horizontal.		Driving circulating pumps	900 r.p.m., 185 lb. steam	Terry Steam Turbine Co.
2	Pumps	Tri-rotary	24 in.	Circulating pumps	900 r.p.m.	Henry R. Worthington
2	Pumps	Duplex	10x10x10 in.	House service	Intermittent	Henry R. Worthington
2	Turbines	Single stage		Driving hotwell pumps		Terry Steam Turbine Co.
2	Pumps	Turbine	4 in.	Hotwell pumps		Henry R. Worthington
1	Heater	Vacuum		Boiler feed water	215 deg.	Warren Webster & Co.
1	Filter	Jewell		House water		New York-Continental-Jewell Filtration Co.
6	Boilers	Water-tube	600 hp	Main steam generators	185 lb. pressure, 125 deg. superheat	Babcock & Wilcox Co.
6	Stokers	Mechanical	8′7″x12′	Dutch oven furnaces	Engine driven	Murphy Iron Works
1	Crane	Traveling	2¼ tons	Handling coal to crusher	As required	Toledo Crane Co.
1	Crusher	Traveling		Crushing coal	As required	Orten Steinberg Co.

to 110,000 volts for the high-tension distribution. The single-phase transformers, of 2100-kv.a. capacity, are of the outdoor type, as are the oil switches.

The lead-covered cables from the generators are carried through the concrete floor of the turbine room and are hung from the ceiling of the basement as far as the slate switchboard. The outgoing lines leave the station through fiber ducts laid in concrete, in three pairs of three-phase cables to the transformers at the outdoor substation, Fig. 9, about 400 ft. from the power house.

All the control switches are in the turbine room. The substation takes care of four 110,000-volt transmission

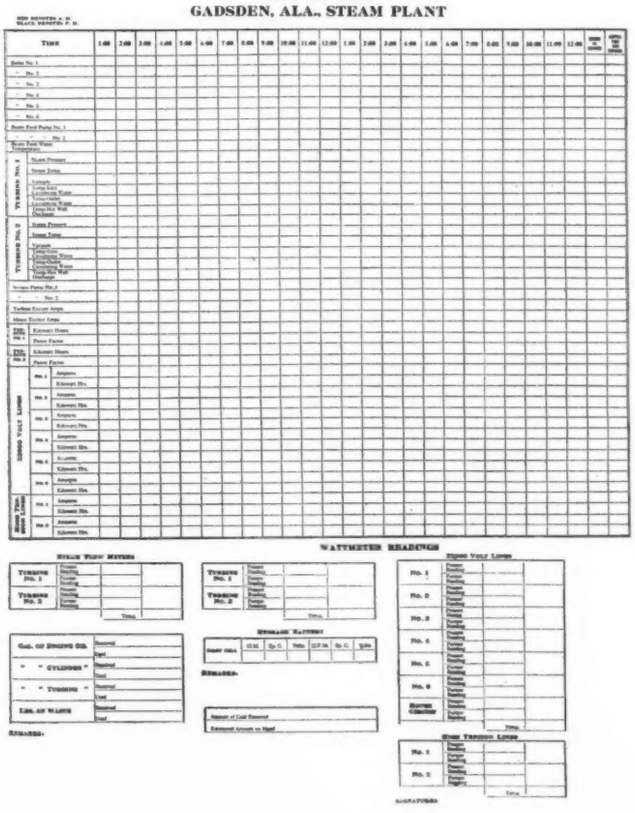


FIG. 10. DAILY LOG SHEET

lines, steps up the voltage from 2300 to either 22,000 or 110,000 volts and steps down the 110,000 volts transmission voltage to 22,000 or 2300.

At present, this power station is used to build up the load for the hydro-electric plant at Lock 12. When this station is in operation, the steam plant will be used as a reserve and operate about 5 per cent. of the time. All 110,000-volt substations now built and to be constructed are, and will be, of the outdoor type of 3000-, 6000- or 10,000-kv.-a. rating.

As in all uptodate power stations, a record is kept of the station performance. The daily log sheet is reproduced in Fig. 10 and takes care of all items of importance.

Rivet-Set Retainer

A rivet-set retainer for pneumatic riveters is made by the Ingersoll-Rand Co., 11 Broadway, New York City. The retainer consists of a single piece of heavy spring steel, closely wound into spiral form. One end fits over the outside of the hammer nozzle and hooks over a projection integral with the nozzle. The other end is wound to a smaller diameter.

Sets for rivets over ⅞ in. in diameter are formed with a coarse thread and are simply screwed into place. Sets for rivets ⅞ in. in diameter and smaller are formed with a shoulder and are slipped into the retainer while it is detached from the hammer, the shoulder holding it in place.

Efficiency—The efficiency of a machine is the rtaio of the useful work to the total work. For example, the efficiency of a boiler is the ratio expressed as a percentage of the heat units utilized in heating the water and raising steam to the total heat units generated by the combustion of the fuel.

Pennsylvania Coal Production in 1913—Pennsylvania mined more coal in 1913, both anthracite and bituminous, than in any previous year in the history of the industry, according to a statement just issued by the United States Geological Survey from figures compiled by E. W. Parker in coöperation with State officials. The production reached the enormous total of 265,306,139 short tons, valued at the mines at $388,220,933. Of this 91,524,927 tons was anthracite, valued at $195,181,127, and 173,781,217 tons was bituminous or soft coal, valued at $193,039,806. The total tonnage broke the previous record for 1912 by 19,079,053 short tons, or nearly 8 per cent., the proportionate increase being about the same for both anthracite and bituminous. The gain in the value of anthracite, however, was $17,558,501, or about 10 per cent., over 1912 and in bituminous coal $23,669,309, or 14 per cent. The total gain over 1912 was $41,227,810, or nearly 12 per cent. The combined production exceeded by more than 20 per cent. the total production of the United States in 1898, only 15 years previous. It exceeded that of any other country in the world, except Great Britain and Germany, and approached within less than 10 per cent. of Germany's output. It was nearly five times the production of the Austro-Hungarian empire nearly six times that of France, nine times that of Russia and Finland, and ten times that of Belgium. It was equal to nearly 20 per cent of the world's total production, and exceeded the combined output of all the countries of the world other than Great Britain, Germany, and the United States. From 1829 to and including 1900 Pennsylvania contributed over 50 per cent. of the total coal production of the United States, and the State still produces between 45 and 50 per cent. of the total.

Heat--A Lecture for Beginners

By Charles H. Bromley

SYNOPSIS—A simple treatment of heat. Tells the beginner what he wants to know about heat as applied chiefly to boiler practice. Temperature, sensible and latent heat, specific heat—all are explained in the beginner's language.

As the boiler is a combined heat generator and heat absorber, an understanding of what the unit of heat is, is essential to a thorough understanding of boiler operation. Heat is a form of energy for which there are numerous explanations, but they are of little practical value to the power-plant man. One of the most essential things for him to know is that the standard quantity or unit of heat in general use in this country is the *British thermal unit* (abbreviated B.t.u.). In practice, this *quantity* is usually considered as that amount of heat required to raise the *temperature* of water one degree F.

Temperature

While the B.t.u. is the *quantity* of heat, the temperature indicates the *quality* of heat. One hundred pounds

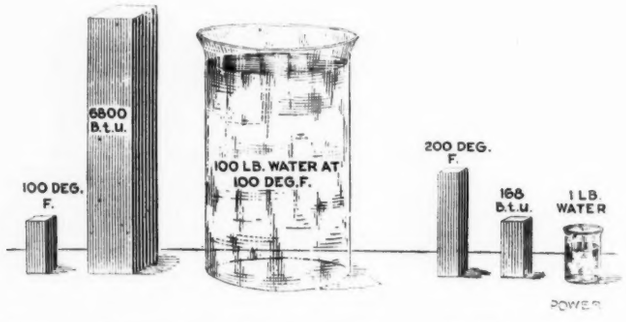


Fig. 1. Showing that Temperature Is Not Alone a Direct Indication of the Amount of Heat in a Body

of water at 100 deg. F. contains more heat than one pound of water at 200 deg. One body of water is twice as *hot* as the other, but it did not take as much heat to make it that hot as it did to make the larger body one-half as hot; see Fig. 1. Remember that temperature indicates only *how hot* a body is; it does not tell directly *how much heat* there is in it.

Pressure, of course, has a good deal to do with heat and temperature as related to water. For instance, as seen from Fig. 1, there is much more heat in the 100 lb. of water at 100 deg. F. than there is in the one pound of water which is at 200 deg. F. Suppose we had the 1 lb. of water under 400-lb. absolute pressure—that is, the pressure as indicated by the gage plus the pressure of the atmosphere or 15 lb.; the temperature would be 444.8 deg. F. The one pound of water would contain 1208 B.t.u. at this temperature—over seven times as much as when heated to 200 deg. F.

Thermometer Scales

The measurements of temperature as we make them are arbitrary. They are made to suit our convenience, as shown by the three standards in use; the *Fahrenheit* scale, which is mostly used in engineering calculations in America, and the British Isles, and according to which water freezes at 32 deg. and boils at 212; the *Centigrade*, used universally, on which the freezing point is 0 deg. and the boiling point 100, and the *Reaumur*, where the freezing point is 0 deg. and the boiling point 80 deg. We see then that

$$1\ deg.\ Fahrenheit = \tfrac{5}{9}\ deg.\ Centigrade$$

$$1\ deg.\ Fahrenheit = \tfrac{4}{9}\ deg.\ Reaumur$$

so that to express the different scales in terms of one another we have:

$$Fahrenheit\ degrees - 32 \times \tfrac{5}{9} = Centigrade\ degrees$$

$$Fahrenheit\ degrees - 32 \times \tfrac{4}{9} = Reaumur\ degrees$$

$$Centigrade\ degrees \times \tfrac{9}{5} + 32 = Fahrenheit\ degrees$$

$$Reaumur\ degrees \times \tfrac{9}{4} + 32 = Fahrenheit\ degrees$$

Absolute Temperature

Put a cake of ice in a room where the temperature is 20 deg. below zero and the ice will eventually *cool off* until its temperature is the same as that of the room; the ice will *give up heat* to the air in the room. We see then that, although ice forms at zero degrees on the Centigrade scale, this is not the lowest temperature that a body may attain; it is not the temperature at which there is a *total absence of heat*, not *absolute zero* beyond which it is impossible to cool a body. Neither are the zero points on other thermometers; man puts them where it is convenient, but the absolute zero of temperature is not fixed by man, Nature having established it for man to discover.

Experiments on the expansion of gases kept at a constant pressure show that the volumes and temperatures increase and decrease proportionately; the volume increasing $\frac{1}{273}$ for each degree Centigrade increase in temperature and decreasing $\frac{1}{273}$ for each degree Centigrade decrease in temperature.

This being so, we see that, *mathematically*, at a temperature of —273 deg. C. or —459.4 deg. F. (the minus sign means negative, means below zero), the volume would disappear. Experiments show that this law, called the Law of Charles, holds true within the limits which we are able to measure. In making calculations in thermodynamics it is sometimes desired to use the absolute zero.

Sensible and Latent Heat

It is important in boiler practice to know how water is affected by heat. At the temperature of 32 deg. F., water changes from a solid to a liquid or from a liquid to a solid; ice forms or melts; it is a *critical* temperature. To melt one pound of ice at 32 deg. into water at 32 deg., 144 heat units or B.t.u.'s must be applied to the ice; and, to freeze one pound at 32 deg. into ice at 32 deg., 144 B.t.u.'s must be taken out of the water. To raise the temperature of one pound of water from 32 to 212 deg., which is the boiling point at atmospheric pressure, 180 B.t.u. must be absorbed, and to cool it from 212 to 32 deg., 180 B.t.u. must be given up by the water. To cool one pound of water from 212 to 32 deg.,

180 B.t.u. must be taken from the water. But, to boil one pound at 32 deg. into steam at 212 deg. will require

$$180\ B.t.u. + 970.4\ B.t.u. = 1150.4\ B.t.u.$$

Remember that this is *above 32 deg. F.* and not above the thermometer zero or the absolute zero.

Notice that the steam is no hotter than the water from which it was produced after the water reached 212 deg., although it took over 5.3 times as much heat to turn it into steam as it did to raise its temperature from 32 deg. to 212 deg.

The mercury in a thermometer placed in the water while it was being heated from 32 to 212 deg., or the boiling point, would have risen from 32 to 212 deg. You could *see* the water getting hotter; the thermometer would show that it was absorbing heat. But, after 212 deg. had been reached, and, although heat were still applied to the water, a thermometer would not show any increase in temperature even though all the water was boiled into steam, and we know that over five times as much heat was needed to make steam of the water as was necessary to get the water ready to make steam. Neither would a thermometer show that it required any heat to melt ice at 32 deg. into water at 32 deg., or to cool water at 32 deg. into ice at the same temperature.

We have just considered the two kinds of heat known as sensible and latent heat. Sensible heat was that amount of heat applied to the water to raise its temperature from 32 to 212 deg. or the temperature at which steam began to form. It was sensible—i.e., it was apparent to the senses; in this case, the sense of sight when we saw the mercury rise in the thermometer. The relative amounts of these two kinds of heat are shown in Fig. 2.

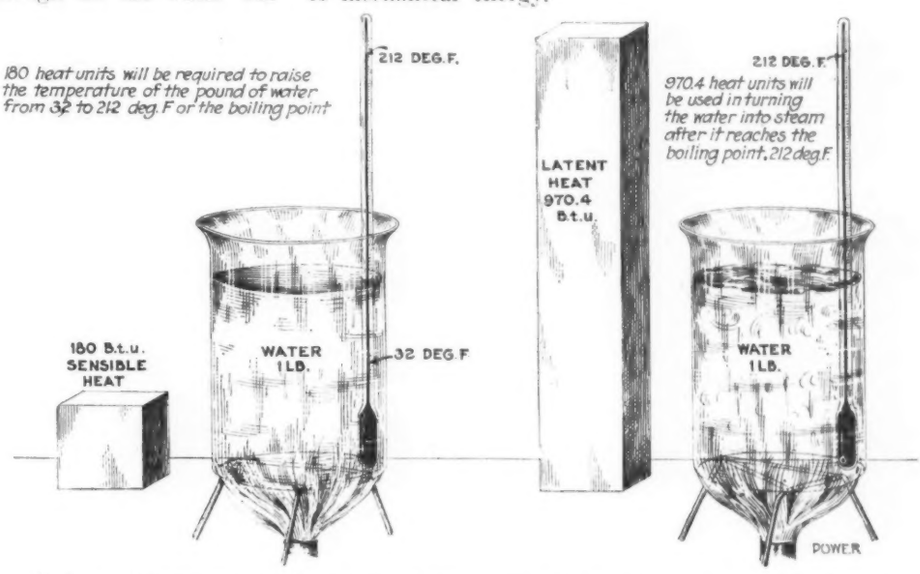

180 heat units will be required to raise the temperature of the pound of water from 32 to 212 deg. F or the boiling point
212 DEG. F.
LATENT HEAT 970.4 B.t.u.
212 DEG. F.
970.4 heat units will be used in turning the water into steam after it reaches the boiling point, 212 deg. F.
180 B.t.u. SENSIBLE HEAT
WATER 1 LB.
32 DEG. F
WATER 1 LB.
POWER

Fig. 2. Showing the Relative Amounts of Sensible and Latent Needed to Boil a Pound of Water into Steam at Atmospheric Pressure

The heat required to make steam of the water at 212 deg. was not apparent to the senses, except that we could see the steam escape as it was made, but we could not detect the added heat by the aid of a thermometer or by feeling the water. The heat was latent, and that is what is meant when *latent heat of vaporization* is mentioned. It is the heat required to turn a liquid into a gas without change of temperature. To boil into steam a pound of water at 32 deg., then, requires 180 B.t.u. of sensible heat and 970.4 B.t.u. of latent heat, or a total of 1150.4 B.t.u. And this latter amount is what is meant when *total heat* or *total heat of the steam* is spoken of, as in the steam tables. *Latent heat of fusion* is the heat that must be taken from a liquid to make it solidify without change of temperature, as when water at 32 deg. F. freezes into ice.

The Mechanical Equivalent of Heat

If a one-pound weight fell from a shelf 778 feet from the ground, it would strike the ground with 778 foot-pounds of energy. This number of foot-pounds is called the *mechanical equivalent of heat*, because with a perfect apparatus it would take the same amount of energy to raise the weight up to the shelf, as it would to raise the temperature of one pound of water one degree Fahrenheit.

So, when it is desired to express heat energy in terms of mechanical energy, we have

$$Mechanical\ energy = heat\ energy\ or\ B.t.u. \times 778$$

and

$$heat\ energy\ or\ B.t.u. = \frac{mechanical\ energy}{778}$$

If a steam plant could use all the heat in the coal it received, then all of this heat would be converted into work at the engine shaft. Thus, from a pound of coal containing 14,500 heat units per pound, we would get

$$14{,}500 \times 778 = 11{,}281{,}000\ foot\text{-}pounds$$

of mechanical energy.

The plant makes use of but very little of all the heat in the coal. The boiler, if handled well, will advantageously use, say, 80 per cent., or

$$14{,}500 \times 0.80 = 11{,}600\ B.t.u.$$

Now of this the engine, which we will assume is a good compound condensing one, will turn into work, say, 19 per cent. of all the heat it receives, which in this case we assume to be 11,600 B.t.u. for each pound of coal burned in the boiler.

$$11{,}600 \times 0.19 = 2204\ B.t.u.$$

For each pound of coal burned containing 14,500 B.t.u. there is available at the engine shaft only 2204 B.t.u. The amount of heat turned into useful work multiplied by 100 and divided by the heat in the coal gives the percentage of the total available heat in the coal that was turned into work, or

$$\frac{2204 \times 100}{14{,}500} = 15.2\ per\ cent.$$

And this amount is called the *thermal efficiency* of the plant.

Specific Heat

You cannot soak up as much water with a wad of paper as with a sponge of equal volume. Neither will a granite

block soak up as much as an ordinary red brick. And so on with various substances; their *capacities* for absorbing liquids are not the same.

The *capacities* of different substances for absorbing heat vary in the same way. If you put one heat unit into a pound of water, which is at, say, 62 deg. F., you raise its temperature one degree, or to 63 deg. F. If you put the same amount of heat into a pound of silver, its temperature will increase 18.1 deg. F., and for lead it would increase the temperature 33 deg.; for copper, 10.75 deg.; for ammonia, 0.99 deg., and so on, each substance having its own peculiar capacity for absorbing heat to produce a given rise in temperature. This is shown in Fig. 3. This capacity is called the *specific heat* of a substance, because that amount will produce a temperature change in a given substance that it will not produce on any other; it is specific for that substance. *Specific heat,* then, is the *heat energy required to raise a unit weight of matter 1 deg. as compared with the heat needed to raise a unit weight of water 1 deg.*

In order to compare the heat required to produce an increase of 1 deg. in some substance, we use water as a standard, for water is in common use and requires one heat unit to produce an increase of one degree; its specific heat is 1, or unity. As used in engineering calculations, specific heat is a ratio; it expresses the relation that exists between two quantities, as

$$\textit{specific heat} = \frac{\textit{heat required to raise 1 lb. of matter 1 deg.}}{\textit{heat required to raise 1 lb. water 1 deg.}}$$

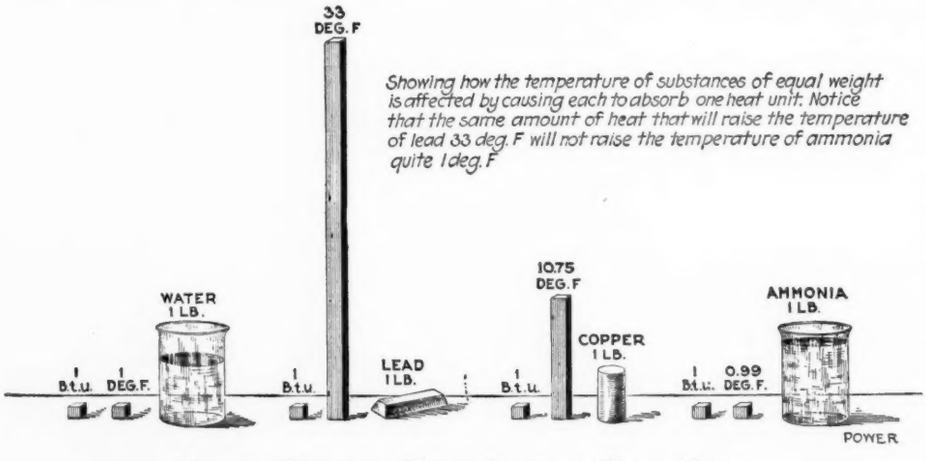

33 DEG. F
Showing how the temperature of substances of equal weight is affected by causing each to absorb one heat unit. Notice that the same amount of heat that will raise the temperature of lead 33 deg. F will not raise the temperature of ammonia quite 1 deg. F
10.75 DEG. F
WATER 1 LB.
AMMONIA 1 LB.
COPPER 1 LB.
LEAD 1 LB.
1 B.t.u.
1 DEG. F.
1 B.t.u.
1 B.t.u.
1 B.t.u.
0.99 DEG. F.
POWER

FIG. 3. SHOWING WHAT SPECIFIC HEAT MEANS

APPLICATION OF SPECIFIC HEAT

In engineering it often is important to know how much heat is required to increase the temperature of a substance one degree, to know its specific heat.

For example, it is desired to know how much heat is carried away by the flue gases per pound of fuel burned. The specific heat of flue gas is generally taken as 0.24—i.e., it takes 0.24 B.t.u. to heat a pound of flue gas one degree. So to find the heat lost in the flue gases, we multiply the weight of gas made by a pound of fuel by the specific heat, or 0.24, and then multiply this product by the difference in temperature between the gases leaving the boiler and the air entering the furnace. The same general method applies for finding the amount of heat absorbed or given up by any substance.

Thermofeed Feed-Water Regulator

A new design of feed-water regulator which operates solely by the water level, independently of the pressure of the steam or temperature of the feed, is illustrated herewith. The apparatus consists of the regulator, which is attached to the boiler or water column, and the regulating valve piped in the feed-water line.

The regulator is a cast-iron body with a water connection at the bottom and a steam connection near the top, at the side. A ball float on the interior is secured to toggle levers and a control valve. Above this valve is a connection with a pipe running to the top of the regulating valve. The control valve consists of a single disk operating between two seats. The valve and seats are embodied in one unit, screwed onto the stem reaching from the toggle in the float chamber to the top of the vertical spindle. The valve and seats together can be taken out for cleaning without trouble, and with the hermetically sealed spun-copper ball float, constitute the moving mechanism controlling the regulation feed valve connected to it by a ¼-in. pipe.

The valve *D* in the pipe connecting the regulator with the regulating valve is made with an upper and lower seat, either of which can be reached by the valve disk by turning the spindle anti-clockwise, that is, to the left, or clockwise, to the right. In the first case, steam communication from the float chamber to the regulating valve is obtained, and in the latter the regulating valve is put in communication with the atmosphere and is, therefore, out of control.

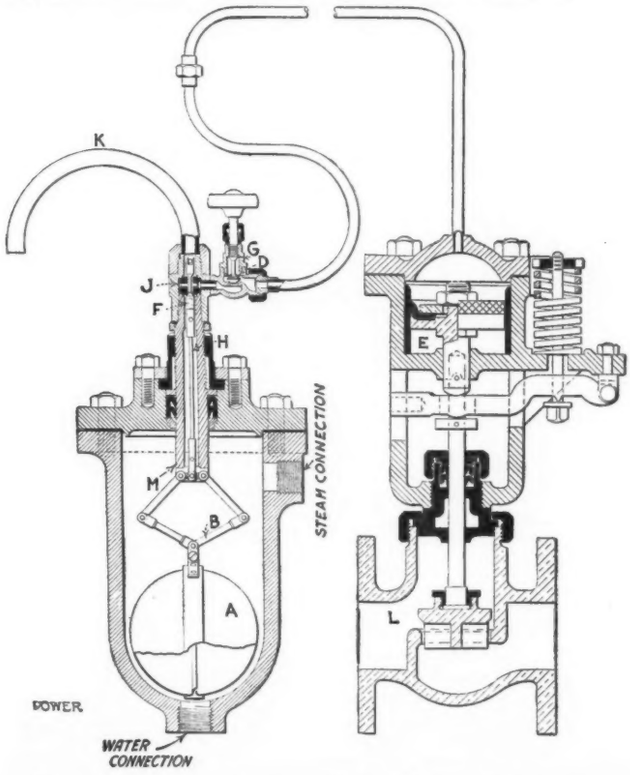
This valve must always be on one or the other of the seats and not in an intermediate position. The illustration will show how it operates. When the double valve is on the upper seat, the cylinder *E* is put into communication with the control valve *F*, and the thermofeed is in commission; when the double value is on the under seat, the cylinder *E* is in connection with the atmosphere through the vent *G*. This puts the regulator out of action and leaves the automatic flow-regulating valve open. The double-seat valve *F* performs the main function of the apparatus and is attached by a rod *H* to the float through toggle levers so disposed as to reverse the direction of motion. Any movement of the float is diminished as 10 is to 1, and the motion is transmitted through the toggle and the rod to the valve *F*.

If the water level and the float fall, the valve *F* is moved to its lower seat, closing any exit of steam through it and simultaneously putting the cylinder *E* in direct communication to the atmosphere by way of the ports in *J* and the exhaust pipe *K*. If the water level and the float rise, the valve *F* is pulled downward on its upper seat, thus permitting the passage of steam through the lower valve onto the piston in the cylinder *E*, and in this way gradually depressing the main regulating valve *L* onto its seat. The controlling mechanism in the

float chamber is attached to the sleeve *M* and can be raised or lowered by turning a nut when in action, thus permitting of adjustment for any permanent water level.

The relay or controlling valve is far removed from the water level, and no dirt or sediment can reach it. The working parts are all of non-oxidizable metal.

This regulator, which is being introduced in this country by the American Steam Gauge & Valve Manufacturing Co., Boston, Mass., is designed to maintain a uniform level with a variation not exceeding ¼ in. for a water-tube boiler, and to give a practically constant feed.



DETAILS OF THERMOFEED FEED-WATER REGULATOR

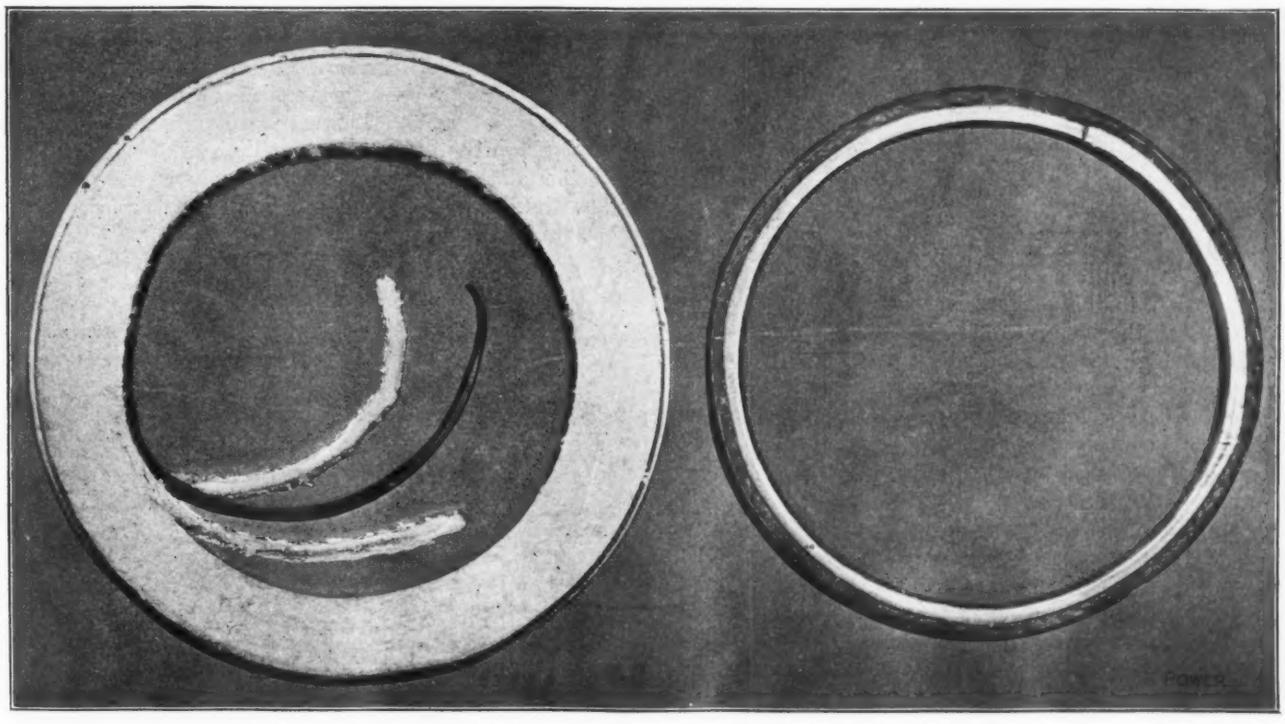
The piston of the regulating valve is packed with S. E. A. ring rubber and asbestos composition packing, as is also the stuffing-box between the water valve and the upper part of the regulator. The spring on the outside of the piston *E* is adjustable, and made in square sections of cast steel.

Flexitallic Flange and Tube-Cap Gaskets

The illustration shows two types of gasket, one suitable for flange joints and tube caps, the other for water-tube boiler caps only. The flange gasket is made up of plies of waterproof asbestos and monel metal, built up at right angles to the line of pressure in one interlocking length, beginning on the inside and ending on the outside of the gasket. This construction, shown at the left of the illustration, eliminates the possibility of the gasket blowing out, it does not stick to the flange surface, and it can be used with superheated steam, water, oil, gas, air, ammonia, acids, chemicals, etc.

This gasket, made by the Flexitallic Gasket Co., Real Estate Trust Bldg., Philadelphia, Penn., is guaranteed to stop all leaks and to remain tight when used with rough surfaces or on pipe lines subject to vibration. When once in place there is no following up, because the gasket takes care of the expansion and contraction and can be used over and over again.

Another kind of tube-cap gasket is made of metal and waterproof-treated asbestos in the shape of a reversed S. The length of treated asbestos is placed in the space formed by the curved ends, which are beaded over the asbestos. The completed gasket is shown at the right of the illustration and is to be used but once.



FLEXITALLIC GASKETS FOR PIPE FLANGES AND BOILER CAPS

Department No. 8 and Special Furnaces*

By Osborn Monnett†

SYNOPSIS—A brief outline of the construction and the principal dimensions of the settings.

One of the latest furnaces perfected by the Chicago Department of Smoke Inspection is shown in Fig. 1.

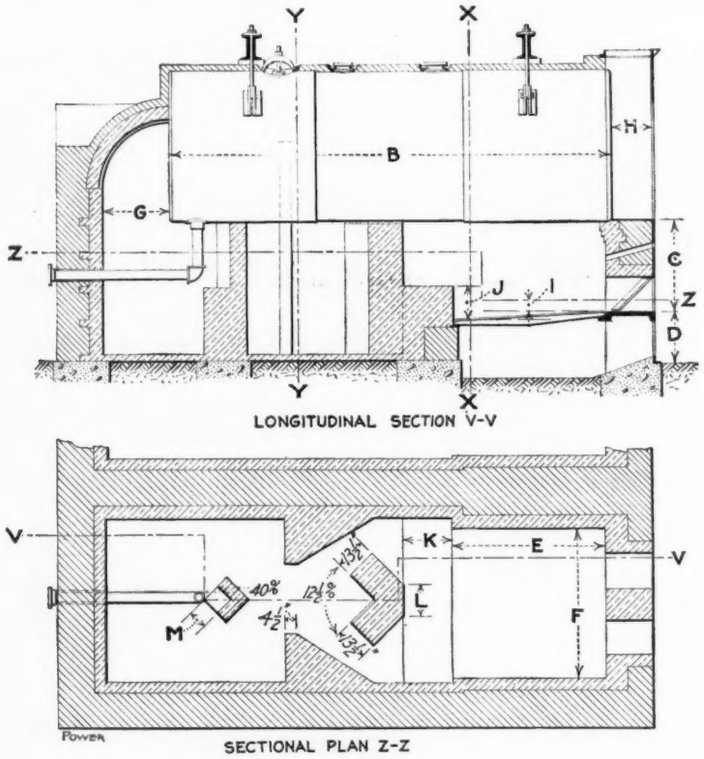
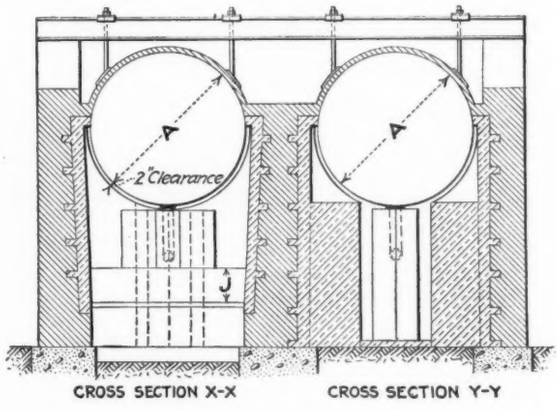


Fig. 1. The Department No. 8 Furnace

It is known as No. 8 and is of simple construction, consisting of a V-pier extending from the bottom of the combustion chamber up to the shell of the boiler and has two wing walls tied into the side walls of the furnace. The gases are thus deflected twice against hot brickwork and squeezed between the two wing walls before they pass to the combustion chamber. In this way the gases are thoroughly mixed and the temperature is found to be high enough for ignition even without arches. The steam jets and panel doors are the same in this furnace as in the double-arch, bridge-wall furnace described in the issue of July 28, 1914. It will be noticed that the side walls contain no air space; they are made solid to conform with the latest practice.

In this furnace an area of 25 per cent. of that of the grate surface should be allowed over the bridge-wall; 12½ per cent. of the grate area should be allowed for each gas pass around the V-pier. The free opening between the wing walls should be not less than 40 per cent. of the grate surface. These proportions give a furnace which works satisfactorily for ordinary power loads.

The McMillan furnace, shown in Fig. 2, is a proprietary furnace corresponding with the ideas previously advanced. It consists of a single-span, firebrick arch, which extends from the back edge of the bridge-wall forward, covering half the grates. Back of the bridge-wall is a V-pier and wing walls which mix the gases much in the same way as the No. 8 furnace. The furnace is equipped with panel doors and has in addition to this a special series of air-admission ducts along the side of the furnace from the front extending back to the bridge-wall. This air admission is controllable by dampers in the side walls and can be adjusted to meet the conditions. The dimensions given in the drawings apply only to a 66-in. by 16-ft. boiler.



Twin Fire Arch

Another patented furnace which has been successful in running without dense smoke is the twin fire-arch furnace shown in Fig. 3. This furnace, with the two just described, provides for direct radiation of the heat into the boiler and a high-temperature zone over the bridge-wall, with a deflection arch as before. The peculiarities of the furnace are as follows:

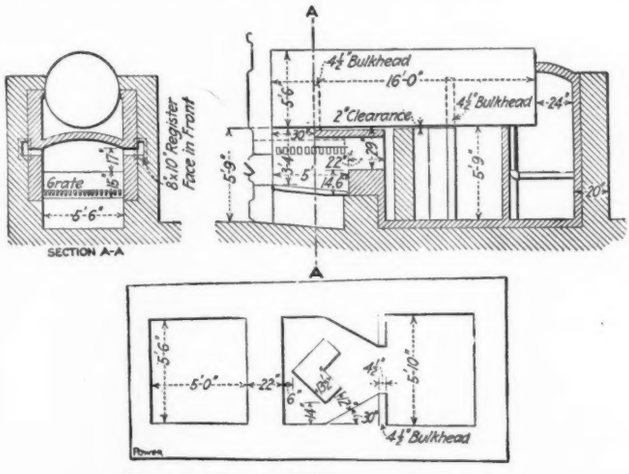


Fig. 2. The McMillan Furnace

*Copyright, 1914, by Osborn Monnett.
†Smoke inspector, city of Chicago.

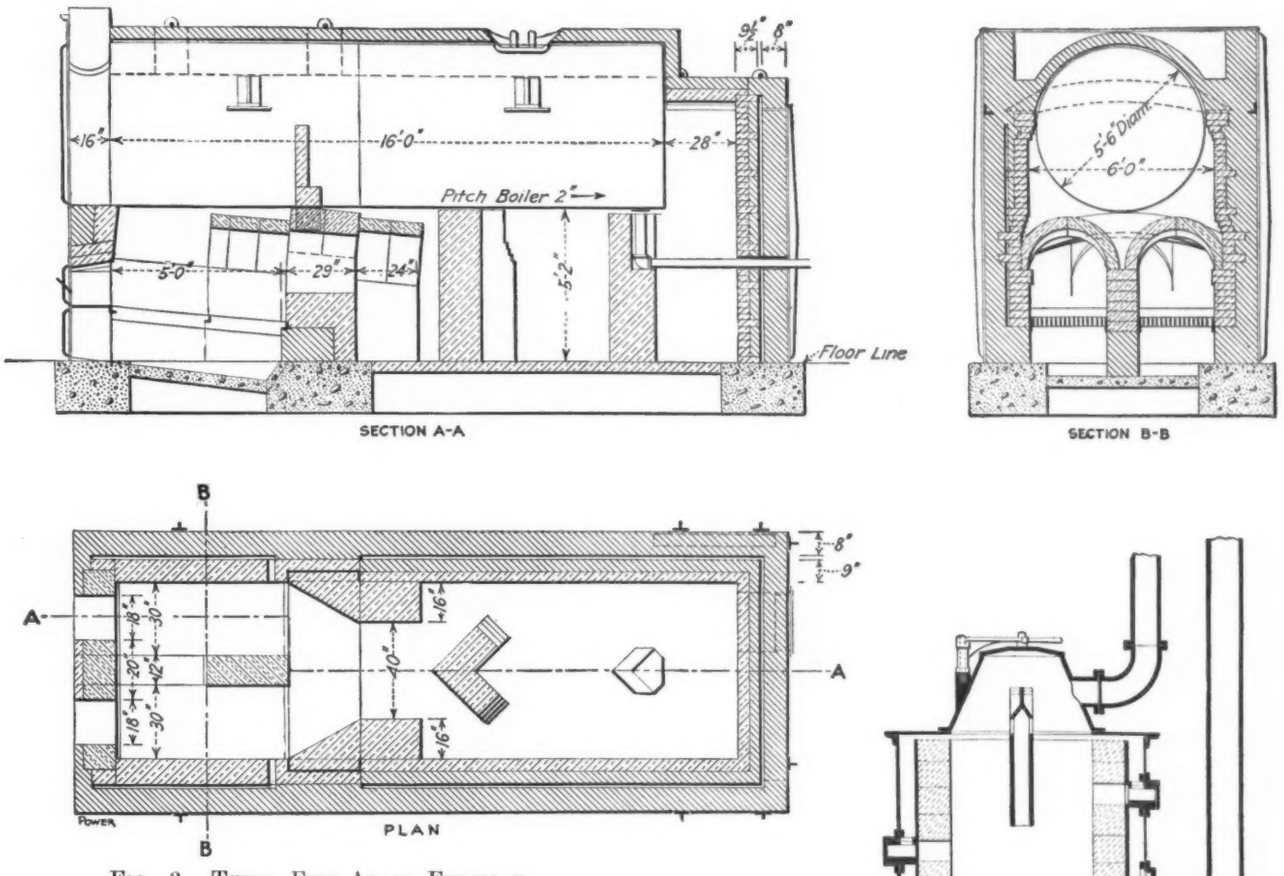


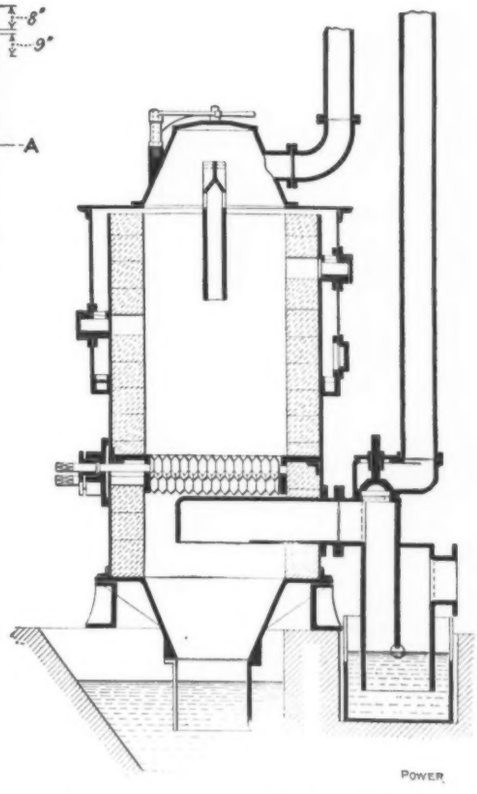
FIG. 3. TWIN FIRE-ARCH FURNACE

Starting with the fire-doors, which are equipped with panels according to the latest specifications, the grates are of the rocking-shaking type, and the arches over the fire are in two spans, or of the twin fire-arch type. Over the bridge-wall there is a single-span arch with a wing-wall construction which contracts the flow of gases as they emerge from the twin arches. The gases next come in contact with the V-pier and are thoroughly mixed. A double-span arch was formerly used in place of the V-pier, but the former kept the gases away from the shell.

Producer for Burning Refuse and Low-Grade Coals

The illustration shows the Kynoch suction-gas producer now used extensively in Australia and New Zealand, where there is an abundance of cheap wood and low-grade coals.

It is of the down-draft type, with a jacket from which heated air is drawn into the fire through special auxiliary air ports. The fuel in the upper part of the bed is partly burned, giving off its volatile constituents. The extra air drawn in through the ports creates an intensely hot zone in the fire, and as the gas containing the volatile matter from the partly burned fuel is drawn through this hot zone by the suction of the engine, the tar is split up, thus eliminating the necessity of a mechanical tar extractor. The auxiliary air ports are adjustable, so that the required extra air can be regulated to suit the quality of fuel and load conditions. The fuel is fed from the top, no hopper valve being necessary, and the condition of the fire can be kept under constant observation.



SECTION THROUGH PRODUCER

Recently a series of full-load tests was carried out on wood and other fuels obtainable in Australia, the fuel burned per horsepower-hour being reported as follows:

	Per Horsepower-Hour, Lb.
Salmon gum	2.3
Mulga scrub	2.2
Box blocks	2.15
Jarrah sawdust and shavings	2.40
Collie coal	1.2
Brown coal (46 per cent. moisture)	1.8
Spent tan bark	3.13
Pine shavings and blocks	2.31

Considering that the majority of the above materials are of low price, and in some cases are simply waste products, the economy in operation is evident.

Testing for Open Circuit

By F. A. Annett

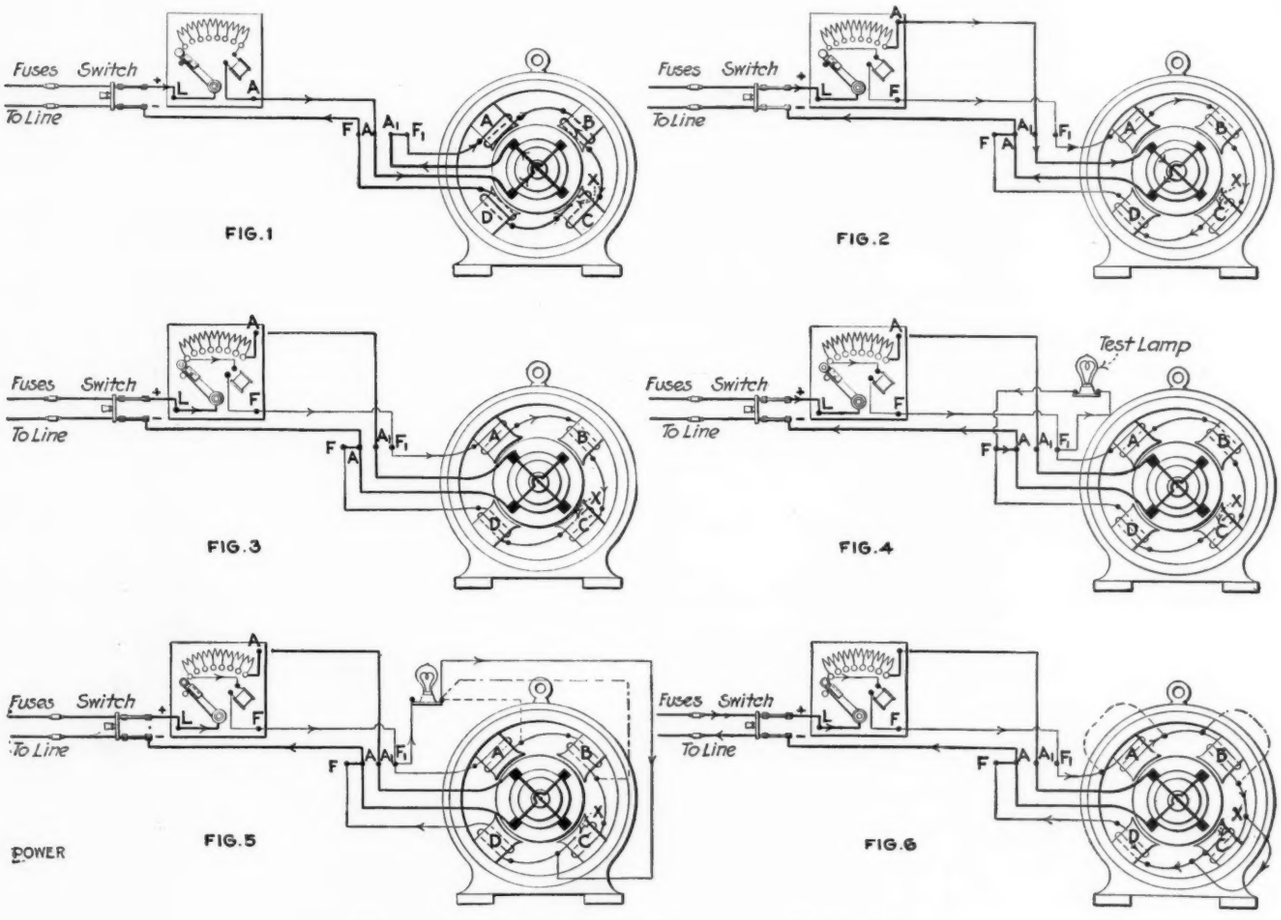
An open circuit in the field coils of a motor may produce several different effects, depending upon the condition under which it occurs and the type of motor. If series wound, the motor cannot start, for the field winding is in series with the armature, as will be seen by referring to Fig. 1, where the field coil *C* is open at *X* and no current can flow through the motor.

In the shunt motor the field and armature windings form two independent circuits; therefore an open-circuit in the field coils will not interrupt the current flowing in the armature; see Fig. 2. In this type of machine a break in the field circuit may produce any of the following effects: The motor, if not loaded, will start if the brushes are not set at the neutral point. The direction of rotation will depend upon the setting of the brushes, but the motor will race and spark, and if an attempt is made to cut out all the starting resistance, the fuses will blow, or the circuit-breaker will open and there is likely to be burning at the commutator and brushes. If the machine is loaded, it will not start, and if the starting resistance is cut out, the fuses will be blown. With the brushes set on neutral, the machine will not start, but if they are given a backward lead, the armature will turn in the opposite direction.

A simple method of testing for an open field where a shunt or compound motor has been operating properly and suddenly develops trouble is: First, disconnect the armature connection on the starting box, as shown in Fig. 3, and move the starting handle upon the first contact. If the field circuit is complete when the arm is allowed to drop to the off position or the switch is opened, a severe spark will occur at the contact; if the field circuit is open, there will be no spark. The break in the field circuit may occur anywhere from the first contact on the starting box around to the line connection on the motor. After determining that the field circuit is open, it is necessary to find out whether the break is in the motor, the external wiring, or the starting box.

A test may be made for a break in the external circuit by opening the armature connection at the starting box, placing the arm on the first contact, as before, and connecting a lamp across the field connection on the motor, as in Fig. 4. If the lamp lights, the field circuit outside the motor is complete, as indicated by the arrowheads.

After it has been found that the break is in the field winding, inspect the connections between the field coils to see that none is broken or loose. After these are found



How to Test for Open Circuit in Field Coils

to be in good condition, the defective field coil may be located as shown in Fig. 5. Place the starting-box arm on the first contact and connect one terminal of the test lamp to one of the field terminals of the motor; in this case to F_1. With the other lamp terminal make connection between coils A and B, as indicated by the dotted line. In this position the lamp will not light for the circuit is open at X in coil C. Next connect the free lead of the lamp between coils B and C, also indicated by the dotted line; again, it will not light. However, when connection is made between coils C and D, as shown by the solid line, the lamp will light, for now the open coil has been bridged. Since the lamp will not light between coils B and C but will light between coils C and D, it shows that coil C is open-circuited. Where a test lamp is not at hand, a piece of wire may be used to bridge one coil at a time, as shown in Fig. 6. First, short-circuit one coil as indicated by the dotted line at A, then close and open the switch. If a spark occurs when the switch is opened, the open coil has been bridged. In this case, however, it does not occur until coil C has been short-circuited, as shown by the full line. After the open coil has been located it should be disconnected and again tested through with a lamp to be absolutely sure that it is defective.

The open circuit often occurs where the leads are connected to the coil winding; this may be easily located and repaired. After the coil has been opened up it should be tested back of the splices where the coil connects to the leads to make sure that the trouble is in the coil itself. In many cases, especially where the coils are not wound on a spool, the open-circuit can be located and repaired without rewinding the coil, for if not found at the points mentioned, it usually can be located in the coil itself by a burned spot on the insulation caused by arcing when the coil opened.

An open-circuit in the shunt field of a compound motor will have practically the same effect as in the shunt motor, except that the motor will usually start whether loaded or not, as the series field will provide sufficient torque to start under full load, but the machine will usually race in either case. The break in the shunt field may be located in the same manner as described for the shunt machine. An open-circuit in the series field will cause the machine to fail to start in the same way as described for the series motor in Fig. 1.

Oils and Lubrication--I

By L. D. Allen*

SYNOPSIS—Selecting an oil; its value as compared to grease, tested and filtered oils, Pennsylvania and Southwestern crudes; simple engine-room tests and specifications of oils for different uses.

"If the salt has lost its savor, wherewith shall it be salted?" This briefly illustrates conditions as to quality that seem to have prevailed to a considerable extent in the oil and grease business. If the lubricant has lost, or rather had taken from it, its oiliness, wherewith shall it be oily? The man who pays the bills usually knows little, outside of shop reports to the effect that "it seems to be all right," concerning the economic qualities of the lubricants for which he is paying. His caution seems to have stopped with having made up his mind that so long as he receives no complaints he will not consider other propositions offering a higher grade of lubricant at the same price he has been paying, or the same quality that he has been using at a lower cost. It not infrequently proves that a better grade at a higher price is, in the end, the most economical.

There is really little that the small user can do other than depend on the experience and reliability of the party from whom he purchases his oil. In the engine rooms of many small plants, however, there are men in charge whose long experience in the use of lubricants enables them to judge closely as to whether they are getting good results. In the case of large consumers it is different. Here, practical shop tests can be conducted with a view to reducing friction and conserving horsepower to an extent compensating the time and outlay. As new materials are constantly being developed, and as a knowledge of their manufacture and uses is constantly increasing, the conclusions of any one test should not be considered final. The tests should be repeated from time to time when conditions seem to warrant it.

*Antifriction specialist, Chicago, Ill.

Selecting an Oil

Standards are constantly changing so rapidly in some lines that the ideas and specifications of a year or two ago must be modified, or perhaps discarded for something different. Up to within the past two years it has been customary to judge the quality and bearing value of oils by their gravity, flash, fire, cold and viscosity tests. Crudes, however, with their different general chemical and physical characteristics, are being produced in different sections of the country that now prove the purchase of oils on a specification basis to be unreliable. In other words, due to changes in the oil industry, and the properties and characteristics of new crudes, the old specification methods are becoming obsolete and cannot be depended upon to give the buyer proper values for his particular bearing requirements. Information as to gravity, flash, fire, cold and viscosity tests is not without value, however, in comparing oils produced from the same crudes.

With this new order of things in the oil line comes a revival of the old adage that "The proof of the pudding is in the eating." The real value of a lubricant should now be determined by what it shows in the plant where its use is being considered. These requirements are:

The oil must show sufficient body to keep the bearing surfaces apart at the load, speed and temperature at which these bearings run. It is desirable to know how low a coefficient of friction it shows compared with another oil in the same bearing and under the same conditions. The flash point must be sufficiently high to meet the temperature requirements of the bearing, otherwise,

reduced lubrication and loss by evaporation is the result. The oil must show proper lubricating fluidity at as low a temperature as it will be compelled to work under. It should show no tendency to decompose or to form deposits or gummy conditions, and it must contain no ingredient that will corrode or pit the bearing surfaces. The oil should be bought from a source that will insure maintenance of the standard adopted.

Few consumers are aware that practically all of the oil and grease dealers, and many so called refiners and grease manufacturers, are really securing the most, if not all, of their products from a few large refiners, although many of these refiners are in direct competition with some of the dealers who purchase their products. It is a wheel within a wheel. The oil and grease user is likely to obtain the same oil, but under a different name, from any one of several concerns soliciting his patronage. On the other hand, the consumer would err if he did not give to each solicitor reasonable attention, courtesy and consideration. A little friendly attention often inspires a solicitor to offer a prospective customer values that he knows should retain that friendship, and at a cost sufficiently low to minimize competitive assaults. Sentiment, when it is mutual, invariably profits both the buyer and the seller.

A noted English authority—matters of this sort seem to be receiving more attention abroad than here—has found that over half of the ten million horsepower in use in England is lost through unnecessary friction, faulty lubrication and inferior lubricants. In factories in this country, where oil and grease bills amount to thousands of dollars annually, experts have found a loss of 50 per cent. or greater. There is serious effort on the part of oil, grease and babbitt manufacturers to coöperate with the trade in effecting economies along these lines, but it is too often construed as a selling rather than a helping effort.

Each Plant an Individual Problem

The writer does not claim to be an expert on oil and greases, nor does he know of any one who may be rightly so considered, for the reason that those longest in the business are conversant with so many exceptions to what at first appeared to be the rule that they refuse, where they have any real regard for their reputation for veracity, to be specific or definite in their recommendations. They know that grades and qualities which work out perfectly in some cases have proved entirely unsatisfactory in others where the conditions seemed exactly the same.

Suppose a man were something of an expert in the manufacture and use of oils and greases, he might be comparatively ignorant on bearing design and construction and on the nature of the material, brass, bronze or babbitt with which bearings are lined, and the suitableness of the method of lubrication for his lubricant in connection with the bearing conditions might escape his attention. Poor, improper or inadequate bearing design or construction is a fruitful source of babbitt and lubricant trouble. The bearings may not be large enough or of the design best for the load and conditions under which they are compelled to work. Lubricating devices may be sold without regard to the kind of bearing, load or conditions. In babbitt and lubricating problems each plant has its individual solution. Babbitt and lubricant manufacturers are more often than otherwise unjustly blamed for troublesome bearing conditions. In ninety-nine cases out of a hundred the fault will be found in improperly designed bearings, in the method of applying and handling the babbitt or lubricant, in the conditions under which they are compelled to work and the attention they get while working.

What is needed is not so much better products as better relations and understanding between the producers and the consumers themselves. Any deal that is not profitable to one is not profitable to the other. The bargain that yields mutual satisfaction is the only one likely to be permanent. The losing customer is the lost customer. The keynote of modern commerce is service.

Some consumers will say that they are well satisfied with the quality and service they are getting, but that they object to being charged an exorbitant price. An old and experienced salesman remarked sometime ago that no one is more responsible for high prices than the consumers themselves. While many appreciate the advantages, yet not enough will buy through letter solicitation. They require that the producer spend thousands of dollars in selling his product. The result is, an article that the consumer figures can be produced for 10c. has really cost the producer 15c. to sell, and he must add another 5c. for his profit. If sold by mail or by advertising the oil might have cost 15c. instead of 20c.

Having factory or engine-room tests made by an experienced lubricating engineer, under the supervision of the plant engineer or millwright, is the proper course for the large consumer to determine what is best for his specific and general requirements. The small consumer must depend on the reputation of the concern from which he is buying, on the selling argument of the solicitor, on testimonial letters, orders, etc.; from other users who are buying the oil under consideration for practically the same kind of machinery, and on such return and refund clauses, in the event the oil does not suit, as he can incorporate in his buying agreement.

The matter of suitable lubrication is quite simple if pure oils from the same crudes are obtained. A quantity each of good motor oil, a good machine oil and a good steam-cylinder stock with a few pounds of tallow, contain the essentials for a wide range of bearing requirements. While there are innumerable brands on the market, yet, with few exceptions, a half dozen oils will cover all general lubricating requirements.

In one case, nine different brands of cylinder oil, five brands of machine oil and a dozen or more different greases were in use. Some were fairly reasonable in price; others inordinately high. In one engine room the engineer needed a certain kind, in other engine rooms in the same building the engineer could not use it; he required something different. For the electrical machinery, another brand was wanted, and in the pump house the operators had their own ideas. A few simple tests were made which convinced the men that one grade of cylinder oil and two grades of engine and machine oil filled every need. It was also proved that but three grades of grease were needed.

Oil vs. Grease

As to the value of oil compared with grease for lubricating purposes, there is a wide difference of opinion. There are some facts, however, that have been quite definitely determined and generally agreed on. As a

lubricant there seems to be but little real difference between the use of a pure, properly refined petroleum oil and a pure properly made oil grease. For tightly keyed journals under high speed and heavy pressure, oils seem to have the preference. The flow and spread are more abundant, so that the frictional heat is conducted away more rapidly. There is less likelihood of acids and gummy conditions in the use of oils, and they can be secured in greater variety as to density. When it comes to slow-moving machinery where the pressure is not great, the practice is in favor of greases.

Of some of the new oils now being produced from various Southwestern crudes, viscosities on straight oils range from 500 to 1000, with gravities as low or lower than have heretofore prevailed on 200 to 300 vicosity lubricants. Their values as compared with grease for the class of machinery referred to remains to be determined. The economy and service in the use of either depend on the bearing conditions, the method of applying, attention, etc.

Grease is admittedly less wasteful; it stops running when the journal stops. However, as grease is more dense or gummy, more power is required in starting, and as sufficient frictional heat must be developed to transform the dense grease body into a fluid oily state, it would argue a loss of power in this process. The re-use of oil gradually diminishes its lubricating properties, and, unless perfect filtration is secured, it must deteriorate in becoming charged with minute foreign substances. Greases containing free acids are injurious to certain kinds of bearing surface and start corrosion and wear. Oils loaded with adulterants containing rosin oil, soap preparations, blown rapeseed oil, etc., while they apparently serve their purpose fairly well, are, due to their gummy nature or acid content, either creating a drag on the journal, thereby wasting power, or are disintegrating the surface of the babbit bearing and heating the journal sufficiently to require the excess use of oil, to say nothing of the expense of rebabbitting oftener than necessary.

Treated Oils

The quality or lubricating body of a pure petroleum oil depends on the quality of the crude and the method of refining. The filtered oils are free from those fatty acids that injure bearing surfaces. The trouble usually occurs with the treated oils. Oils filtered through fuller's earth and boneblack contain the lowest percentage of free carbon. It is usually the oil treated with sulphuric acid that affects the surface of bearing metals. In the purchase of oils it is impossible, regardless of one's experience in the oil business, to determine a filtered oil from an acid-treated oil. This can be distinguished only through tests that show ash determination. A filtered oil will show from 0.001 to 0.002 of 1 per cent. of ash, which is usually iron oxide, whereas an acid-treated oil will show from 0.5 to 0.07 of 1 per cent. of ash, usually sodium sulphate, sodium carbonate and iron oxide.

It is the high temperatures that cause oils to decompose, and, naturally, those treated by acid decompose more readily, increase in acidity and pit the bearing surfaces; also, when oils decompose, the fluid or intermolecular friction increases.

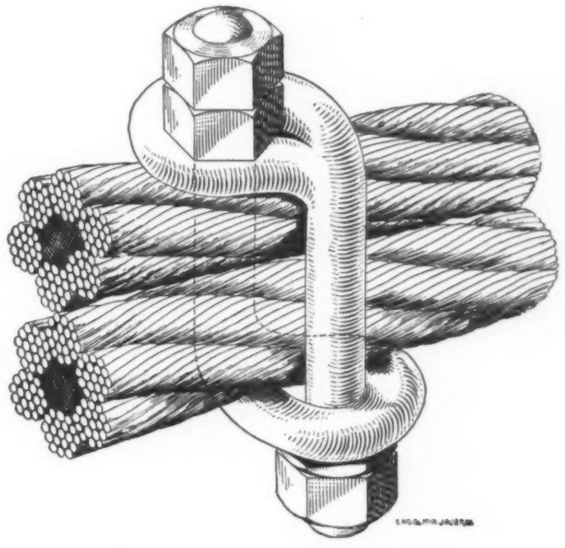
One of the most exacting duties of the refiner is said to be the treatment with caustic soda in such manner as to remove all acid products without overdoing the matter and producing an emulsion. In acid-treated oils it is necessary to wash them with caustic soda to neutralize the acidity. It has been proved that it is impossible to wash out entirely the mineral salts formed during the treating process. Tests of oils treated and then filtered through fuller's earth and boneblack show a higher percentage of ash than those that were only filtered. This brings out the point that it is impossible to obtain an oil of the highest lubricating qualities by treating it with acid. The presence of free alkali, sodium sulphate or sodium salts of organic acids are injurious to metallic surfaces. They start corrosion on the surface of the babbitt lining and shortly the result is a rebabbitting expense for which the babbitt often is, but should not be, blamed. Babbitt compositions of tin, lead and antimony resist the influence of these acids better than bronze bearings, the heavier content of bronze bearings being copper.

Home-Made Cable Clamp

By Walter R. Hodge

The chief virtues of the clamp illustrated here are simplicity of operation, ease of fabrication and tenacity of grip. An ordinary blacksmith can easily turn out a dozen an hour.

For ¾-in. cable, the clamp is made of ⅜-in. iron bent



Application of Cable Clamp

into a 1¼-in. eye and welded. A shank 3 in. long is threaded half its length and turned at an angle of 90 deg. to the plane of the eye and two nuts are provided for each shank. The clamps are used in pairs, the shank of one being shoved through the eye of the other with the two thicknesses of cable between and the nuts placed and tightened and locked with the extra nuts.—*The Engineering & Mining Journal.*

The Word "Zero" is from the Spanish, and means empty, hence nothing. It was first used for the thermometer in 1795 by the Prussian merchant and physicist Fahrenheit.

Air Compressors Driven by Keokuk Power

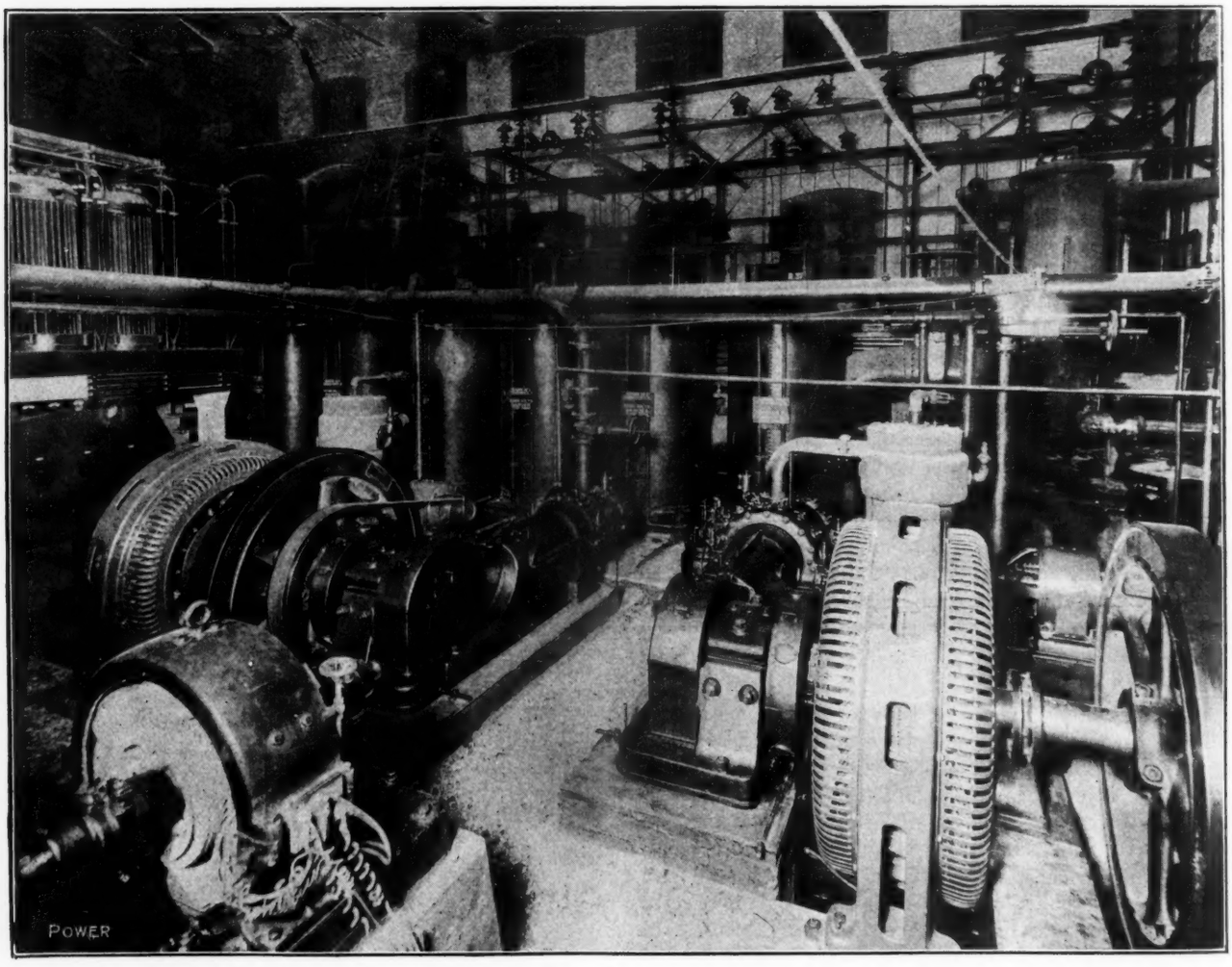
SYNOPSIS—One of the first private plants to be operated by power from the Keokuk power plant is that of the Atlas Portland Cement Co., Hannibal, Mo.

In August, 1913, the steam-driven air compressors of the Atlas Co. were replaced by three Sullivan cross-compound air compressors, with 26 and 15¼ by 18in. cylinders, each machine having a capacity of 2000 cu.ft. of free air per minute. These compressors are directly connected to General Electric 400-hp synchronous motors, running at 187.5 r.p.m., using three-phase, 25-cycle, 220-volt current, stepped down at the transformer station from a voltage of 33,000, at which tension it is transmitted from the Keokuk plant, on the Mississippi River, about sixty miles distant.

An average receiver pressure of 100 lb. is maintained by means of total-closure unloading valves on each machine. These unloading valves are operated automatically, so that a 5 per cent. regulation is obtained in receiver pressure.

To supply the present demand of the plant, the energy input to the compressors will average about 12,000 kilowatt-hours per day. The principal use for this air is found in a blast supplying pulverized coal to rotary kilns and for drills in the limestone quarry. Air is also supplied to the machines in the blacksmith shop for operating hammers, hoists, drills, etc., and there are outlets at convenient points throughout the plant for cleaning motors and other apparatus.

This installation was made by the Stone & Webster Engineering Corporation, of Boston, and is the first large compressor plant of its kind operated by power from the Keokuk plant.



Air Compressors, Motor Driven by Energy from the Keokuk Power Plant

The illustration shows the motors directly connected to the crankshaft of the compressors. The large step-down transformers for the compressors and for other purposes in the works are shown at the rear and side of the room.

We are indebted to William H. Baker, superintendent of the Atlas Co. for the foregoing data.

Kebec Boiler Circulator

A circulator for internally fired boilers has been designed with the aim of producing a simple, automatic device, requiring no special attachment to the boiler and which can be installed during the time required for cleaning or inspecting the boiler. It is the Kebec circulator, made by the Klein Boiler Circulator Co., 30 Church St., New York City.

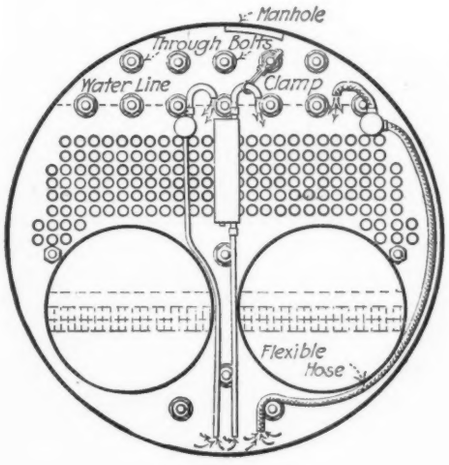


FIG. 1. VERTICAL TYPE OF CIRCULATOR

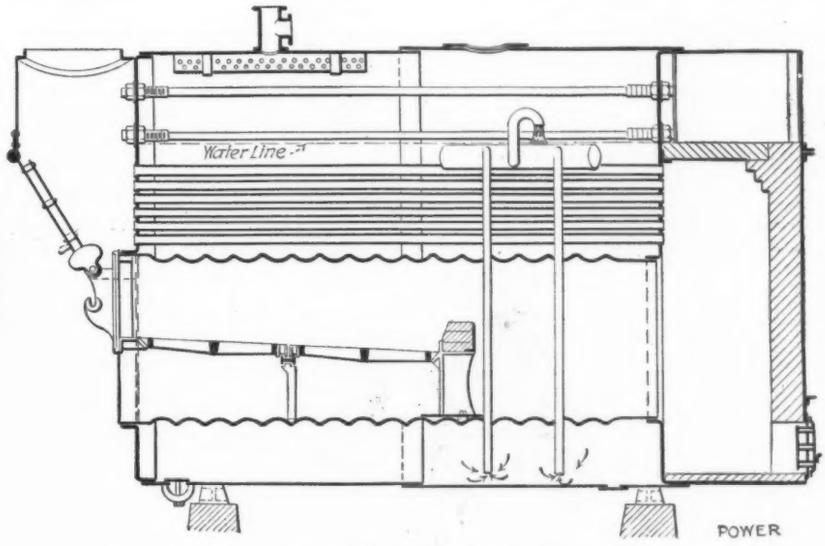


FIG. 2. HORIZONTAL TYPE OF CIRCULATOR

The circulator, of simple construction, can be placed in a boiler by inserting it through the manhole. It is necessary that the circulator body be covered with water at all times; the opening of the gooseneck must be several inches above the highest water level.

This device is of two general types. In the vertical type, Fig. 1, the body of the circulator hangs vertically between the groups of tubes and is fastened with a simple clamp on the through-bolt of the boiler; the inlet pipe comes near the boiler bottom and the discharge pipe above the water level.

The horizontal type, Fig. 2, is placed in boilers where the flues are so close together that a small space only is left between them. Hence the body of the circulator has to be placed horizontally above the flues with the suction pipes passing through the space between them, to the bottom of the boiler. The discharge pipe is above the water level. When the condition of the boiler is such that the suction pipes have to be bent, the circulator is equipped with flexible copper or bronze hose, Fig. 1, which can be formed according to the shape of the boiler or of the furnace.

The device is automatic in operation, is self-contained, and is operated by the physical law of vacuum and pressure created in part by the alternate heating and cooling of air, combined with the factor of differential water levels.

The circulator raises the cold water from the bottom, then warms and discharges it in the steam space, forcing the hot water to flow into the lower part of the boiler, thus maintaining an equal temperature throughout the unit.

The result of tests made to show the efficiency of the circulator is graphically explained by the diagrams, Fig. 3. The test was performed with a 200-hp. Continental Scotch-marine boiler. One thermometer was placed on the top, and another on the bottom. The first test was made without a circulator; the temperature on the bottom in 8½ hr. rose to about 329 deg. F. In the same boiler a circulator was installed and a second test showed that after the fire had been started at the same hour as previously, the water in the bottom was the same temperature as at the top in an hour's time.

The curve *a* shows the reading of the thermometer on top of the boiler; curves *b* and *c*, the reading of the thermometer on the bottom with and without the circulator. The difference between the curves *b* and *c* shows the advantage of the circulator in the boiler.

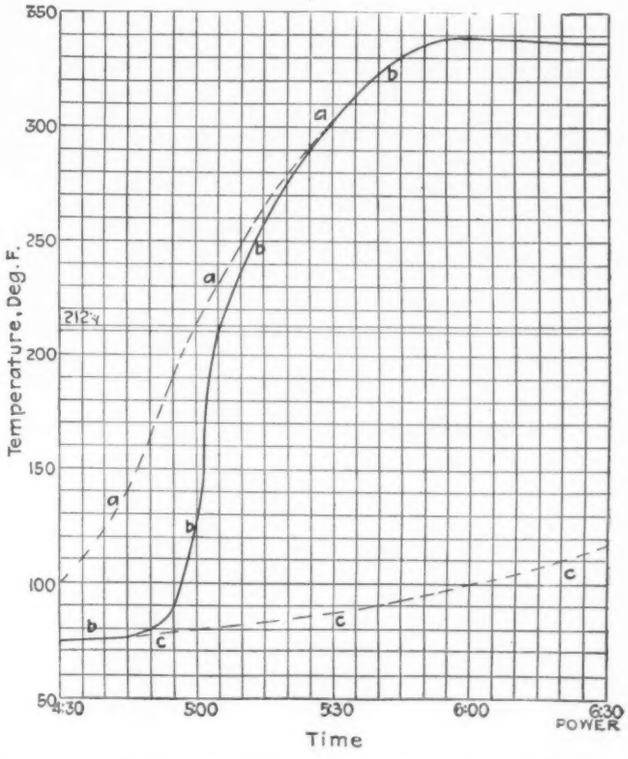
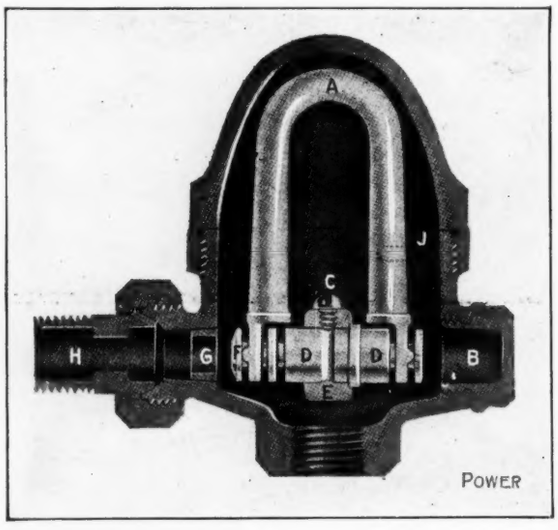


FIG. 3. SHOWING TEMPERATURE OF WATER IN BOILER WITH AND WITHOUT THE CIRCULATOR

Vento Automatic Valve

The Vento automatic valve, for vacuum or vapor heating, is a shell containing a copper-plated spring-tempered steel tube *A* filled with a volatile fluid hermetically sealed and so sensitive that a change in temperature of one degree is sufficient to operate the valve.

The cap nut *B* is for inserting the valve mechanism and to test the operation of the valve while it is in service. The cap screw *C* fastens the valve mechanism to the supporting bridge *E;* the sleeve D is the mounting for the valve mechanism and acts as a guide for the valve *F*, and also so supports the tube *A* that the movement of the tube must open and close the valve. The supporting bridge *E* is part of the valve body to which



Section through Automatic Valve

the sleeve *D* is secured. The bronze valve head *F* is moved back and forth by the tube *A*, the guide *D* holding the tube *A* in a central position.

Before steam is turned on, the thermostatic tube is neutral and the valve is then wide open, and remains in that position until all of the air and condensation have been removed from the point to be drained. The instant steam arrives, however, the tube *A* expands, closing the valve tight. As condensation forms, the temperature lowers and the tube contracts, moving the valve from its seat and discharging the water. This valve is made by William S. Haines & Co., Twelfth and Buttonwood Streets, Philadelphia, Penn.

Regulation of Power Rates

By A. L. H. Street*

The following review of decisions announced by some of the highest courts of the country during the last few years serves to show that companies selling electric or other power to the public are as much subject to regulation of their rates by public authorities as are railroads, and upon the same general ground—that is, on the ground that they are quasi public corporations.

By asserting the right to condemn land for public use, it has been held that a power company estops itself to deny the power of the state to regulate its rates and service and to prevent discrimination. (Tennessee Supreme Court, Great Falls Power Co. vs. Webb, 133 *Southwestern Reporter,* 1105.)

In another case a hydro-electric power company has been declared by the Wisconsin Supreme Court to be a "public utility," and, as such, subject to state regulation of its rates and prohibition against discrimination in charges. (Village of Kilbourn City vs. Southern Wisconsin Power Co., 135 *Northwestern Reporter,* 499.) The court finds that a contract which runs counter to such regulations is invalid. The California Supreme Court has also declared that, on account of their quasi public nature, electric power companies are restricted to reasonable charges, which may be fixed by municipal ordinance. (Ex-parte Goodrich, 117 *Pacific Reporter,* 451.) Again, the North Carolina Supreme Court has decided that an electric company, by devoting its property to public service, becomes subject to regulations as to the maximum rates which it may charge. (Horner vs. Oxford Water & Electric Co., 69 *Southeastern Reporter,* 607.)

Power of Courts Defined

Although a court has jurisdiction to determine whether a rate complained of is reasonable, it has no power on reaching a negative conclusion to prescribe a reasonable rate. "In a case of this character, the court can review the action of the rate-making body only so far as to determine whether, under the rate presented and the other rates which the complainant may lawfully charge, it will be unable to realize a fair and just return on the value of its property devoted to the particular public use, and will amount to a taking of its property without just compensation." (United States District Court for the District of Oregon, Portland Railway, Light & Power Co. vs. City of Portland, 200 *Federal Reporter,* 890.)

Rates established by proper authority are presumptively reasonable. (Arkansas Supreme Court, Arkadelphia Electric Light Co. vs. City of Arkadelphia, 137 *Southwestern Reporter,* 1093.) Hence, when it appears that a city has been vested with power to fix rates, the burden is on a power company in suing to restrain enforcement of an ordinance prescribing rates to show that they are unreasonable or confiscatory. (Portland case cited above.)

Rates Considered as a Whole

A power company is not entitled to a reasonable profit upon each transaction, and a regulation of rates is valid, if a fair return will result from the rates as a whole, although a reasonable profit may not be derived from a small class of customers. (Missouri Supreme Court, State vs. Water, Light & Transit Co., 155 *Southwestern Reporter,* 826.)

Existing and unexpired contracts for power are impliedly subject to a reduction on lower rates being validly established by legislative authority. (Portland case.)

The courts have gone so far as to hold that although a public-service corporation is entitled to reasonable compensation for service rendered, it cannot legally suspend operations because of a reduction in rates. The remedy is a suit to enjoin enforcement of the law or ordinance prescribing such rates, if the same be unreasonable. (Florida Supreme Court, City of Gainesville vs. Gainesville Gas & Electric Power Co., 62 *Southern Reporter,* 919.)

*Attorney and counselor-at-law, St. Paul, Minn.

Legislative Power Is Delegable

The legislature may delegate its rate-fixing power to a public-service commission or other administrative body, to be exercised in conformity to standards established by the legislature. (New York Supreme Court, Appellate Division, Third Department; Village of Saratoga vs. Saratoga Gas, Electric Light & Power Co., 107 *New York Supplement,* 341.)

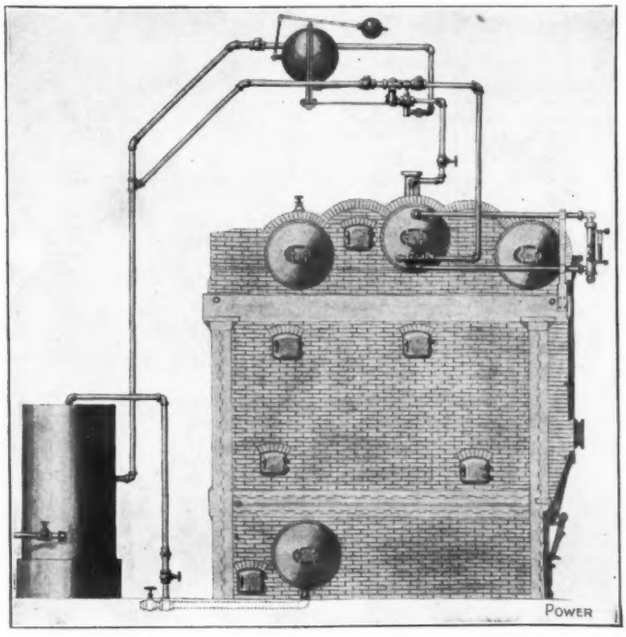
The constitution of Florida has been interpreted by the state supreme court as being broad enough to authorize the legislature to empower a municipality to fix reasonable gas and electric rates. (Gainesville Gas & Electric Power Co. vs. City of Gainesville, 58 *Southern Reporter,* 785.)

A city cannot fix rates unless clearly so empowered by its charter. (United States Circuit Court for the District of Minnesota, Minneapolis General Electric Co. vs. City of Minneapolis, 194 *Federal Reporter,* 215.)

A law authorizing a public-service commission to pass upon the reasonableness of rates charged by power companies supersedes previous charter provisions empowering cities to fix such rates. (United States District Court for the District of Oregon, California, Oregon Power Co. vs. City of Grant's Pass, 203 *Federal Reporter,* 173.)

Reiter Continuous Blowoff Boiler Cleaner

Depending upon the quality of the feed, impurities in greater or lesser quantities are deposited in a boiler in the form of mud, sludge and scale. To keep the boiler steaming properly, these impurities must be removed



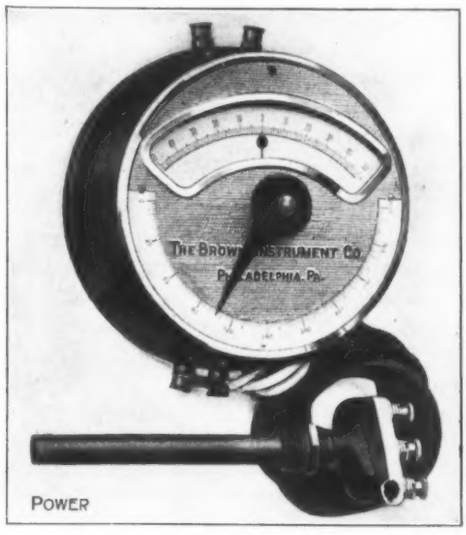
Continuous Blowoff Cleaner

periodically. It has been customary to pump up one or two gages and to blow down once or twice a day, and sometimes oftener. This procedure tends to remove the impurities, but it allows them to remain in the boiler for some time and entails the loss of considerable water which has been previously heated.

To save this lost energy, the National Boiler Specialties Co., Elgin, Ill., is putting out the device shown in the illustration, which consists chiefly of a settling tank and a return trap. As may be seen, the tank is connected to the mud drum of a Stirling water-tube boiler. The blowoff is left open to carry the sludge over to the tank continuously and as soon as it is formed. It is then deposited in the bottom and the water, freed from its impurities, is returned to the boiler by the return trap shown at the top of the illustration. The piping is selfexplanatory; means have been provided to keep the trap from becoming air-bound. For this arrangement a practically clean boiler and the attending advantages are claimed, also the saving of the hot water otherwise blown to the sewer.

New Brown Resistance Thermometer

A new resistance thermometer has been brought out for measuring temperatures from 200 deg. below zero to 1800 deg. F. This instrument is adapted for low temperatures which cannot readily be measured with the thermo-electric pyrometer, and is particularly useful for indicating the temperatures in dryers and ovens, in machine bearings which may overheat, in motor windings and in transformers, on refrigerating machines and in



Resistance Thermometer

rooms which must be maintained at a constant temperature.

The instrument, manufactured by the Brown Instrument Co., Philadelphia, Penn., consists of a bulb or coil of resistance wire through which a current is passed, and which changes in resistance with a change in temperature. Bulbs at numerous points around the plant are connected by three-wire cable to the indicating instrument and switchboard, which can be placed at any desired point. In determining the temperature, it is simply necessary to switch any bulb on to the indicating instrument, as shown in the illustration. If a constant temperature is to be maintained, the pointer can be adjusted to this temperature and its deflection on the upper scale will show the increase or decrease. This instrument operates on either dry cells or storage batteries, or 110- or 220-volt direct-current lighting circuits.

Its chief advantages are the ability to read moderate temperatures from one central location without the necessity of going about from one point to another to read it as indicated on thermometers, and in the fact that the bulbs are of metal and not liable to be broken as is the case with a glass thermometer. The indications are guaranteed to be within 1 per cent.

Water-Hammer in Boiler-Feed Lines

By Albert H. Israel

In plants where the feed water is at a temperature of 212 deg. F. on the suction side of the pump, and where the head of water above the center of the pump cylinder is low, water-hammer generally occurs on each stroke of the pump. This trouble is experienced in many plants, but exactly what takes place in the pump cylinder is not generally understood.

On each suction stroke a partial vacuum must be produced in the water cylinder before the difference in pressure on the two sides of the suction valve disks becomes sufficient to open them. If the pressure on the suction side were high enough, the water would rush in immediately when the piston starts forward. The water being at the atmospheric boiling temperature, some of it immediately passes into vapor when the pressure in the cylinder becomes lower than the pressure of one atmosphere. But to take in water, this difference must be maintained, and thus at the end of the suction stroke there is considerable vapor present in the cylinder. On the discharge stroke, the piston, finding a cylinder partially filled with steam, rushes down upon this and stops suddenly when it strikes the solid body of water, which cannot be compressed, causing a loud knock due to the sudden impact. This is transmitted through the entire pressure side of the feed line, and not only causes excessive pressure for the instant, but also is productive of line leaks. There are various ways in which these may be prevented, some of which are:

(1) Lower the temperature of the water flowing to the pump. This would in most cases solve the problem immediately, but should never be resorted to, for, although effective, it would prove uneconomical.

(2) Raise the feed water heater or the utility tank. In any case the water should flow to the pump by gravity. Many think that because the level of the water in the heater is above the cylinder of the pump, this requirement has been satisfied, but this is not always so, because the whole, or at least a large part, of the head of water available, is required to overcome the friction of pipes and fittings.

(3) Avoid an excessive loss of head due to the friction in piping. Often the pipe is too small for the water required, so that an excessive loss of head due to friction results from high velocity. Unnecessary bends and other fittings should be left out of the line when not absolutely required. When valves are required, only gate valves should be used, for these give the minimum resistance to the flow.

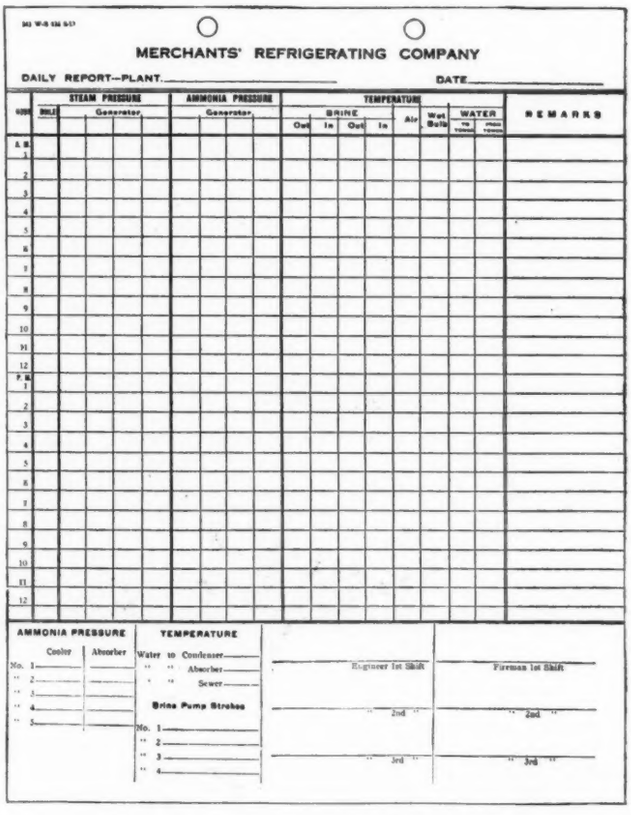
(4) Lower the feed pump. This is a good method to stop the hammering when it is possible to adopt it. When the direct-acting feed pump is replaced by a moderate-speed triplex belt- or a motor-driven feed pump, in addition to the lowering, then the desired result is doubly assured.

(5) Do not use springs on the suction valves of the pump which are too heavy. If too great, a difference in pressure on the two sides of the disks is required to open them; the greater part of the available head may be lost in overcoming their resistance to opening.

The particular method which may be employed to best advantage in any case will depend upon the conditions. Sometimes a combination of several ways becomes advisable, depending on the location of the plant in the building, headroom, etc.; the layout of the piping and the money available for the purpose.

Absorption-Plant Report Sheet

The form shown is used for the daily-report sheet in a large absorption plant. Several other forms were drawn up, but this one proved best suited to the needs. The sheet is 8⅜ in. wide by 10¾ in. long and is perforated at the top to allow inserting in a loose-leaf


MERCHANTS' REFRIGERATING COMPANY

DAILY REPORT—PLANT._____ DATE._____

HOUR	STEAM PRESSURE Generator	AMMONIA PRESSURE Generator	TEMPERATURE BRINE Out	BRINE In	BRINE Out	BRINE In	Air	Wet Bulb	WATER In	WATER Out	REMARKS
A.M. 1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
P.M. 1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

AMMONIA PRESSURE	Cooler	Absorber
No. 1		
" 2		
" 3		
" 4		
" 5		

TEMPERATURE	
Water to Condenser	
" " Absorber	
" " Sewer	
Brine Pump Strokes	
No. 1	
" 2	
" 3	
" 4	

	Engineer 1st Shift	Fireman 1st Shift
	" 2nd "	" 2nd "
	" 3rd "	" 3rd "

Log Sheet for Absorption Plant

folder. An atmospheric cooling tower is used, which accounts for the columns "Air" and "Wet Bulb." The "Remarks" column would be better if made wider.

We should be pleased to receive good daily-report and summary sheets from a compression plant. The sheets should be thorough and yet not burdened with useless items.

Flotation—A body lighter than water will not rise unless the water can get under it. Thus, if one side of a block of light wood perfectly flat and smooth and varnished to exclude moisture be placed on a similarly prepared surface on the bottom of a vessel and held there until the vessel is filled with water, it will then remain at the bottom due to the unbalanced downward pressure of the water.

Editorials

An Unconstitutional License Law

Laws providing for the examination and licensing of engineers are passed to insure the public against danger from the careless or unskillful handling of power-producing apparatus—not to make a corner in engineers.

Buffalo has an ordinance which prohibits any owner of a steam plant from permitting other than a licensed engineer to run it, or other than a licensed engineer from running such a plant, but denies a license to any but a citizen of Buffalo.

In 1912 came one F. R. Williams, of Syracuse, to Buffalo looking for a job. He applied for a license and was refused on account of the above ordinance, whereupon he brought a charge of conspiracy against the National Association of Stationary Engineers and the International Union of Stationary Engineers, and pleaded his own case in court. The bill against the organizations was dismissed, but Judge Hazel, in the United States Circuit Court, handed down the opinion that the provisions of the charter and ordinances with regard to the granting of licenses are unjust, discriminatory and void in that they impair the complainant's right by preventing him from following his trade in Buffalo.

The examining authorities in New York City will get a similar jolt just as soon as anybody has the nerve to contest one of their refusals under their similarly restrictive law.

Emergency Stops

We fought the Revolution for our own freedom, the Civil War for the black man's freedom. Freedom from tyranny of all kinds was, is and ought to be the guiding principle of all our laws, and there are still more laws needed when conditions can exist to permit the following, a story from real life and probably true, except in details, of many engineers:

This man is in charge of a 1500-kilowatt steam turbine, the emergency stop on which is completely out of commission. When he asked that it be put in order by the manufacturers' experts, his superiors not only paid no heed, but showed their displeasure in a way that warned him to hold his tongue if he did not want to lose his job. Having a family of small children, he cannot afford to be out of work, so he has to put up with things as they are.

Twice within the last few months the turbine has lost its vacuum from low water in the pond. Fortunately the engineer was near enough to pull the chain that trips the weight and shuts the steam off. The turbine is usually slightly overloaded, and when the vacuum is lost the turbine slows down. Had the engineer not been around at the time, the speed would have fallen until the turbine dropped its motor exciter, which would have meant dropping the whole load. Then, rid of its burden, it would have speeded up until it probably would have burst with disastrous results. This man is all alone and has to supervise the engine room and the men in the fire room. When he goes on his tours downstairs, his mind is perpetually and anxiously on the turbine.

Worry like this is life-shortening, even if it does not drive him to suicide, and if the turbine explodes he is likely to be killed. Then the bereaved family will be even worse off than if he lost his place. No matter how it is viewed, this engineer is up against a losing game.

In the name of consistency, wherever there are laws or ordinances compelling the provision of safety valves on boilers and safety devices on elevators and periodic inspection of both, and this should be wherever human life and property are jeopardized by them, there should also be compulsory provision of emergency stops on turbines and engines and their frequent inspection. Just so long as an employer's selfishness or indifference can make it necessary for a man to work in such mental torment as has been outlined, we are far from being a free country. By contrast the life of a galley slave in the days of ancient Rome was a sinecure.

Perfecting Laws

The engineers in most states would be so glad to get any boiler-inspection laws at all, that they are not prone to be too particular. Poor laws, however, may be worse than no laws and it is sometimes harder to get amendments than the original laws, so that all those working for legislation in their states will do well to strive to get the best laws passed in the first place. To this end the experience of other states already having laws of the kind can be studied to advantage.

Ohio was one of the states that did not have this privilege to any great extent, Massachusetts being the only state that had adequate boiler-inspection laws ahead of it. Good use, however, was made of the Massachusett's experience, and the laws, as first adopted, were very commendable. Then, to make doubly sure of a good job, the boiler inspectors licensed by the state to inspect under the provisions of the Ohio State Boiler Inspection Law, of which there are now about one hundred, organized the Ohio State Boiler Inspector's Association to intensify their influence in perfecting the law. In the words of its treasurer, F. P. Somers, "Any new law of this description is bound to have some rough spots in starting out, and we recognized that as individuals we could do nothing to smooth out these rough spots, but as an association we could and have done a vast amount of good."

Socially and for business the association occasionally meets with the Ohio State Board of Boiler Rules and the chief state inspectors. The rules laid down by the board are discussed and some have been changed, some abolished and some new ones made in consequence. In this way a friendly spirit of coöperation has been estab-

lished between the members of the board and the inspectors that has been of great advantage.

Ohio now has a first-class boiler law, well administered by high-grade men without any friction, and the boiler owners and the public at large have reaped the benefit.

The three ideas, then, that we wish to leave with all who are working for boiler laws in the states still without them are these:

Get a boiler law;

Get the best law possible at the start;

Organize, if necessary, to perfect the law as soon as experience in its operation develops its defects.

Business Grease

Woven in with a valuable article on oils and lubrication, page 169, is a homily on business relations between buyer and seller that applies just as much to other lines as to oils and greases. The article is by L. D. Allen, and from among its nuggets of good sense we have selected the following as especially deserving the emphasis of repetition on this page:

A little friendly attention often inspires a solicitor to offer a prospective customer values that he knows should retain that friendship, and at a cost sufficiently low to minimize competitive assaults.

Sentiment, when it is mutual, invariably profits both the buyer and the seller.

What is needed is not so much better products as better relations and understanding between the producers and the consumers themselves.

Any deal that is not profitable to one is not profitable to the other.

The bargain that yields mutual satisfaction is the only one likely to be permanent.

The losing customer is the lost customer.

The keynote of modern commerce is service.

Salesmen have a way of saying they have "sold" such and such a customer, which unfortunately is sometimes literally true. What they mean, however, is that they have made a sale to that customer. Carrying out the above admonitions the customer will not be "sold" in the sense of being deceived. Mr. Allen can well be considered an anti-friction specialist in more ways than one. With the above suggested lubrication in the dealings between the buyer and seller they should work smoothly together.

Use Allen's Business Grease.

Making Up Lost Education

Men are often heard deploring their lack of education who might just as well educate themselves, no matter what their ages. There are some things that a man loses the ability to learn as he grows older. A boy fourteen can do certain tasks in a cotton mill better than he will ever be able to do them again. This does not apply to mental processes. Some of the best minds have matured late, but they have ripened thoroughly and deeply. In these days of cheap paper, cheap printer's ink and the linotype, there is a wealth of educational material at every man's elbow.

The most common feeling among men who did not make the most of their schooling, or who were obliged to quit school young, is one of despair of ever being able to read intelligently. They got the idea in the little time while they were in school that education is a thing which requires hard study and persistent oversight. That is wrong. The best education there is comes almost unconsciously. The painful part is the getting familiar with the tools of education—reading, writing and arithmetic, and a little more of the same sort of stuff—at an age where it is natural for a child to prefer going fishing, and when he cannot realize the value of these tools.

The two hardest tasks that the writer can remember were to spell "chisel" and to learn the multiplication table up to 12 times 12, which he never uses above 10 now. He wanted a chisel and his father promised him one when he could spell the word. He got the chisel, but he earned it. In school there was no reward; there was punishment and the hatred that went with it.

When men are older and begin to wish they had stuck it out and got an education, they are apt to think that the only way to get it is to start where they left off, and go on as if they were children again. On the contrary, that is the child's way of being educated and not the man's way. They pick up books on some subject that they feel they ought to know about and they find that they are entirely unable to understand them. They despair of beginning over and they cannot read what they find that applies directly to what they want to know. The trouble is that most books are written by men who learned what they know from the standpoint of the so called educated man. The cart is before the horse when the man who got his education by hard knocks looks at it. For him about all there is printed that is right end to are the trade papers, the catalogs of manufacturers and the standard handbooks.

Suppose you want to know how high to set a water tank to get a pressure of thirty pounds per square inch. You find in a handbook a rule which will give you the answer, but it will not tell you why the rule is right. You try to apply the rule to oil or gasoline and it will not work, because it is not water. A textbook will tell you all about it, but it is under the title, "hydrostatic head," which may not mean a thing to you, and the less it means the more likely it is that you need to know. The other thing you can do is to look in the back numbers of the papers until you find something of the kind, or else write to the editor and ask him to publish something about it. The textbook writer cannot be expected to do this because his profit lies in writing the kind of book that will sell best—the kind that college students can read and will be impressed with because of its apparent difficulty.

The main problem in self-education is to find the right reading matter. Get it as simple as necessary for a beginning and the more difficult reading will later become easy.

Boston is paying $103 per year per arc light. Let's see. Was not Massachusetts one of the first states to adopt a Public Service Commission?

Maximum efficiencies to the engineer are like the fixed stars to the mariner; though neither can be touched, they are invaluable as guides to the right way.

Now is the time to begin arranging the educational program for the coming season. Organizations which wait until October will find themselves handicapped.

The elevator operator who makes a habit of depending on the automatic to stop the car at the top of its travel is another of those didn't-know-it-was-loaded fellows.

Correspondence

Allowance for Expansion

Under the above heading, on page 25, July 7, W. Burns says some things entirely new to me. I have had no experience with connecting rod-end bearings (or other bearings) that would expand away from the pin, and I have never seen a crankpin gripped enough to slow down the engine. I have seen them smoke and flash fire, but the engine did not slow down until the throttle was closed.

My rule is to make all adjustments when the parts are expanded, the first thing after shutting down after the day's run. I do not think the type of rod end has much to do with the safe adjustment of the boxes.

L. JOHNSON.

Exeter, N. H.

Boiler Explosion in Hawaii

I have been much interested in POWER's accounts of boiler explosions. Here are illustrations showing an exploded boiler in Hawaii.

Fig. 1

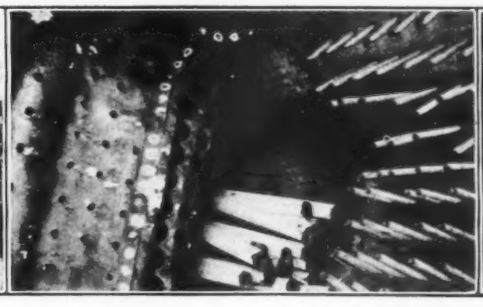


Fig. 2

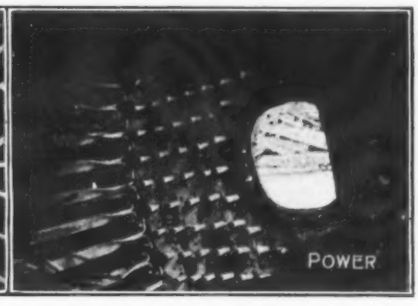


Fig. 3

CONDITION OF THE BOILER AFTER THE EXPLOSION

The explosion occurred one Saturday afternoon about 4:20 p.m. and was the result of low water. The native Hawaiian fireman was killed and his body blown into the street about 60 ft. A passerby was badly hurt by flying timbers, etc.

The locomotive type boiler was one of a pair used to operate a coal hoist and conveyor. Fig. 1 shows where it fell after flying about 150 ft. through the air and describing one complete somersault before it stopped. At the lower part of Fig. 1 the edge of the torn crown-sheet may be seen.

Fig. 2 shows the interior of the firebox, with the crown and tube sheets pulled off from the stay-bolts and tubes and folded back upon the front of the firebox. The white spots are small patches of scale. Fig. 3 is another interior view of the firebox looking toward the door, showing the stay rods and the stay-bolts supporting both the crown-sheet and the front of the firebox. At the left side of the firebox door and at the lower side the plate tore like a sheet of paper.

I believe the crown-sheet gave way first above the fire-door. Few of the stay-bolts were broken, and these were broken probably when the boiler struck the ground and rebounded. All the stay-bolts show that they had been very hot, and some of the heads had small blisters.

No. 2 boiler was tilted over on its side and it is a wonder that it did not explode. Steam poured from every broken connection and there was some noise! Here in Hawaii there is no law that requires boilers to be inspected and no license law for engineers or firemen.

CHESTER E. BLACOW.

Paauilo, Hawaii, T. H.

Preheating Furnace Air

On page 24 of the July 7 issue, Mr. Olmstead describes the means to preheat the air for combustion. In our plant the air is preheated, but in a different manner. The ceiling of the boiler room is low and the air is drawn over the tops of the boilers to the forced-draft fan, which is housed in and connected to this area only. This air is usually about 150 deg., which saves considerable coal and helps ventilate the boiler room. This system has given good results for several years.

Although there may be some reasons for not doing so, it seems to me that the condensation referred to should go back into the boilers, where it would do more good than heating the air for combustion. If it contains oil it can be purified. The amount of saving by putting the hot water directly into the boiler would be 12 to 14 per cent. if the makeup water is cold.

Another waste of heat is in the flue gas. In many of the larger plants economizers are installed, which use part of it, but in the average small or medium-sized plant no attempt is made to save any of this heat, which is usually at from 450 to 600 deg.

Some time ago the air for heating a certain building was blown by a fan through a heater in the breeching of the boiler and heated by the waste gases. This system in some instances might have its good points, although it would require frequent cleaning and would decrease the draft to some extent. This same idea might

be used to advantage in heating the air for combustion provided there was forced draft. I know of one instance in which the hot air from over the tops of the boilers was used by means of a fan to heat the adjacent workrooms, but on account of the amount of gas in it, and also the soot, it was discarded for direct radiation.

J. C. HAWKINS.

Hyattsville, Md.

While the device used for preheating is ingenious, yet a closer analysis would seem to indicate that he must look to something else than his preheater for this saving.

Let us assume that the preheater is capable of raising the temperature of the air supplied to the furnace to the same temperature as the water, namely, about 200 deg. F. from an initial temperature, of say, 60 deg. F. Since the specific heat of air at constant pressure is 0.2375, this preheating of 140 deg. would amount to a heat absorption per pound of dry air of

$$140 \times 0.2375 = 33.25 \text{ } B.t.u.$$

Since one pound of coal burned under usual conditions requires about 22 lb. of air (allowing for a reasonable excess), the preheating per pound of coal burned would be about

$$33.25 \times 22 = 731.5 \text{ } B.t.u.$$

no allowance being made for the heat picked up by the small amount of water vapor present in the air. Assuming that the coal is completely burned and has a heat value of 14,500 B.t.u. per pound, the amount of heat supplied to the furnace per pound of coal burned would be only about

$$731.5 \div 14{,}500 = 0.0504 \text{ or } 5.04 \textit{ per cent.}$$

of the heat of the fuel burned.

He gives no data by which the steam consumption of the pump which circulates the water can be computed, but since most small pumps are notorious for their steam consumption, it seems probable that when this item is considered, any apparent advantage to be obtained from preheating the air in this manner will vanish.

WILLIAM A. DUNKLEY

Atlantic City, N. J.

Compressor Air Supply Stopped

This seemingly bad case turned out to be due to a very simple and natural cause. A Crowell rotary belt-driven air compressor, giving about 150 to 200 cu.ft. of air per minute, at 15 lb., had done good service for over a year, when suddenly it began to fall off, both in its quantity and pressure of air. The chief mechanic did all that seemed possible to repair it, cleaning the relief valve, etc., but in vain; it would not compress.

Finally, the brilliant idea occurred to us that since there was an outlet for the air there ought to be an inlet. The inlet was covered with fine wire gauze, about 70-mesh, to keep out anything that might be detrimental to the compressor. (This happened at a woolen mill, where the air may be more or less filled with all sorts of flocks and lint.) We found the gauze completely covered with a peculiar mixture of fine lint, dust and grease, which acted practically as though the screen were varnished. When the screen was cleaned the air compressor did its work as intended.

C. S. PALMER.

Newtonville, Mass.

Operation of the Venturi Meter

It was stated in the March 24 issue that, in a properly constructed venturi tube, the two cones of the meter might be separated at the narrow part, and yet the swiftly moving water at this point would jump the gap without escaping.

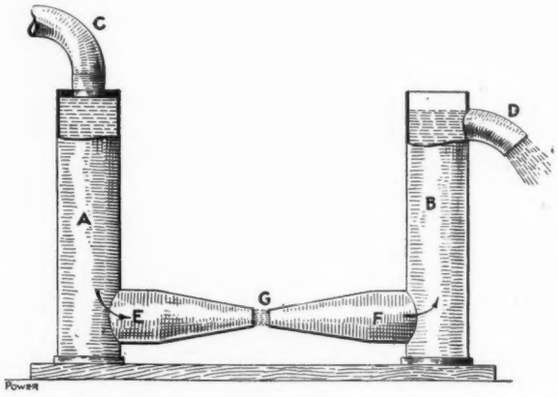


FIG. 1. GLASS MODEL ILLUSTRATING FLOW IN VENTURI METER

Fig. 1 illustrates a glass model which demonstrates this peculiar action. Water is supplied continuously to the cylinder *A* by the pipe *C* and at such a rate that the level is maintained in the former at the top. As the water approaches the small end of the cone *E* its speed is greatly multiplied. The liquid then jumps the short open space *G* without leakage, begins to lose some of its velocity as it travels along the cone *F*, and finally rises nearly to the top of the cylinder *B* to be discharged through the outlet pipe *D*. In other words, from a point of no pressure (atmospheric pressure) at *G*, the water has actually flowed "up hill" against a considerable head. What has really happened is that the head or pressure in *A* has been temporarily translated into velocity at *G*, and then back again into the head in *B*. Upon trying the experiment it will be noticed, however, that the water level in *B* does not stand quite as high as in *A*, due to the slight friction loss.

The interior contour of a standard venturi meter tube is shown by Fig. 2. The shorter or inlet cone extends from *A* to *B*, the flow taking place in the direction indicated by the arrow, the outlet cone is about four

FIG. 2. CONTOUR OF A STANDARD VENTURI METER TUBE

times as long as the inlet cone and the entire outline corresponds closely to the form taken by the flowing water in passing through the meter tube at rates ordinarily met in practice. Those unacquainted with the principle of the meter often refuse to believe that practically as much water can be put through a venturi tube as through an equal length of straight pipe of the same diameter as the tube inlet and under the same pressure. They argue

that if such were the case, they would make all of a pipe line the same diameter as the contracted part, or throat, of the meter tube, losing sight of the fact that the throat is very short and that pipe friction depends upon length as well as upon diameter.

Engineers "from Missouri" have to be shown by checking the readings of a pressure gage in the pipe line preceding the meter tube, before and after the meter is installed, with all conditions of operation identical. If pressure gages are inserted at *A*, *B* and *C*, Fig. 2, their hands will stand at relative positions, as illustrated, showing a decided drop in pressure at the throat but apparently a full regain at the outlet end. Actually, in commercial meters, there is a loss in pressure between *A* and *C* of one-quarter pound for normal rates and one pound for maximum rates within the measuring range of the meter.

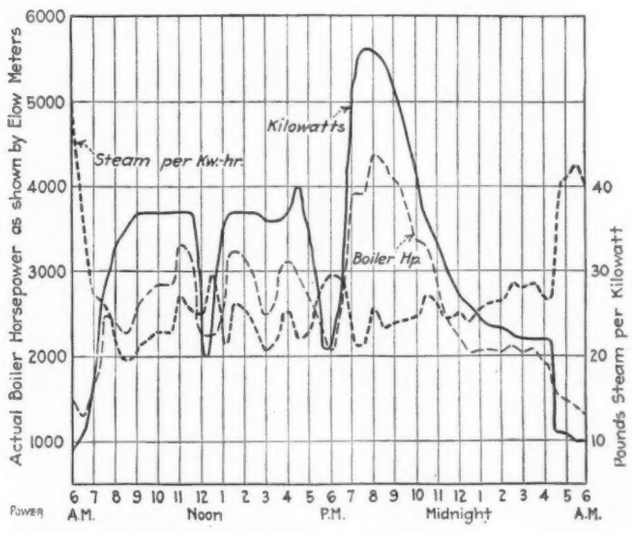
The throat *B* is made from one-third to one-half the diameter at *A*, and the difference in pressure at *A* and *B* varies from $\frac{1}{16}$ to 10 pounds. This difference always bears a definite relation to the velocity of the liquid through the throat. The throat velocity and the throat area being known, the volume in gallons or cubic feet is easily computed. In actual practice, ordinary pressure gages are never employed because they are not sufficiently sensitive to small variations in pressure. Their use also involves the taking of frequent readings and tiresome calculations to determine the actual pounds, gallons or cubic feet discharged in a given period. Various forms of indicating, recording and registering instruments are on the market which are adaptable for giving direct readings in any units desired.

CHARLES G. RICHARDSON.

Providence, R. I.

Utility of Flow Meters

The indicating steam-flow meter is one of the most useful additions to the boiler room in recent years; with a large number of boilers and all kinds of firemen, it



READINGS PLOTTED

has become almost indispensable. The engineer can detect a boiler that is not steaming properly, whether it is the fault of the fireman, the coal or the boiler, or perhaps all three together. At regular intervals, readings of the meters on all boilers should be taken, including the ones banked. The flow meter has shown that banked boilers will produce considerable steam just after renewing the banks, a fact not generally known before.

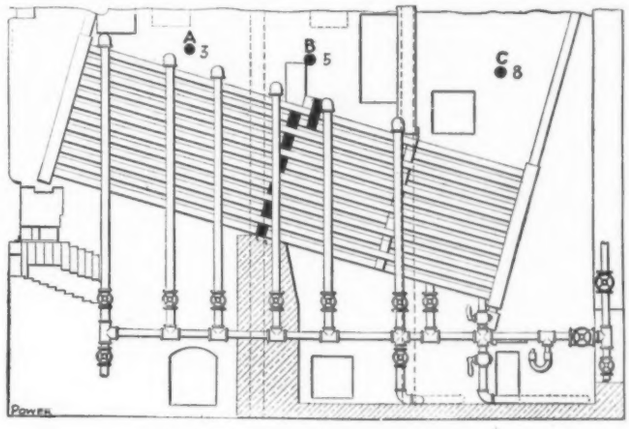
By using these readings a curve can be plotted showing the required boiler horsepower at any interval. In a central station the use of simultaneous wattmeter readings will determine the required boiler horsepower per kilowatt-hour or the pounds of steam per kilowatt-hour.

JOHN F. HURST.

Louisville, Ky.

Soot Blower Pipe Corrosion

On some of our boilers the piping of the soot-blowing system lasted only a few months before it wasted away internally. At first the trouble was thought to be due to



DRAFT AT DIFFERENT POINTS

water of condensation standing in the lines, but a thorough system of drains was installed which proved the fallacy of this idea. It was found that the operator had been leaving the individual valves open on the branch lines. The result was that the difference in the draft between the front and rear of the boiler caused a circulation of gases through the soot-blowing pipe outside the setting, which, mixing with the moisture present, formed a highly corrosive acid. By keeping all the branch-line valves closed when the blower was not in use the corrosion stopped.

The illustration shows the amount of draft at points *A*, *B* and *C*, which will explain how a circulation of gas through the pipe was possible. This was the only trouble of this kind in our plant for years.

JOHN F. HURST.

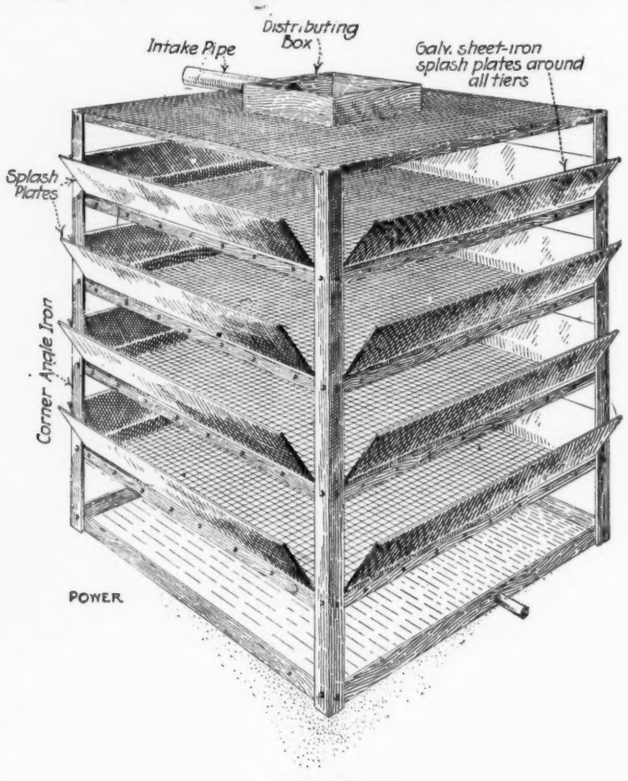
Louisville, Ky.

New Cooling-Tower Design

Visiting a new power plant recently, I saw what was apparently a light and efficient cooling tower. It was situated on the roof of the plant and was arranged as in the illustration.

The frame was of angle-iron corner posts, with horizontal ties of 2x4-in. cypress, bolted to the corner angles at intervals of about three feet. To these ties were fastened one-quarter-inch mesh galvanized wire gravel

screens, stretched across the tower to distribute the water. The distributing box at the top was also of galvanized sheet iron and wire screen. Instead of the usual wooden siding or splash boards, galvanized sheet-iron plates were



COOLING TOWER

used supported by brackets. The parts are easily repaired or replaced and the cost of maintenance is small.

Water is broken up into a fine mist after spreading itself over the screens before falling to the next lower one. The tower has proved remarkably efficient in the hottest weather compared with other towers not using forced draft.

B. W. DENNIS.

Columbus, Ohio.

Thrust Bearings

Turbines with vertical shafts or other heavy machines running on such shafts, exert a great pressure on the step bearing, and it is difficult to keep it cool for two reasons. The lubricant is squeezed out of the bearing and there is a tendency, due to centrifugal force, for it to be worked out to the periphery, where it runs off; and there is no good way to get it back to the center. There are many cases where the position of the bearing renders lubrication specially difficult.

In these instances it is well to employ anti-friction bearings, with conical rollers. These must be arranged exactly radially, with all their axes in a plane exactly at right angles to that of the shaft; and so that they may not touch each other. These three points being taken care of, there will be a great reduction in the friction, assuming that the rollers are of the same diameter and taper and of good, uniformly hard metal.

In one test the weight on the bearing was 8000 pounds; the bearing had an area of 76.58 sq.in., making 104.5 pounds per sq.in.; the power required to rotate the shaft by a pull on a radius of 10½ in. with a plain bearing was 400 pounds. With a conical roller bearing, the area and load being the same, 20 pounds only was required to rotate the shaft. In the first case, the coefficient of friction was 0.05; in the second, only 0.0025.

In freezing weather, when oil will not flow down to the footstep of a water turbine, about the only way to keep the step in good condition is to use roller bearings.

ROBERT GRIMSHAW.

Dresden, Germany.

Handy Soft Hammer

Every engineer realizes that a copper hammer or one of some other soft metal is almost a necessity around the power plant, although it is sometimes impossible to get the company to see it. An engineer can usually have a cheap, serviceable hammer by melting some old babbitt or lead pipe usually to be found around the plant and pouring it into a suitable mold.

The mold may be made as follows: Clamp together flatwise two pieces of 2x4-in. hard wood about 6 in. long. Bore a hole 2½ in. in diameter by 4 in. deep (half of the circle in each block); then at the center gouge out a socket to hold the eye core. Make the core out of a piece of hammer handle, slightly tapered, so that it may be easily driven out. With the core in place, clamp the mold in the vise and pour in the metal. When cold, the mold may be taken apart and the eye core knocked out.

This hammer will stand a lot of hard usage, and when broken it may be recast. Molds for different sizes can be made as wanted, and if taken care of they will last or years.

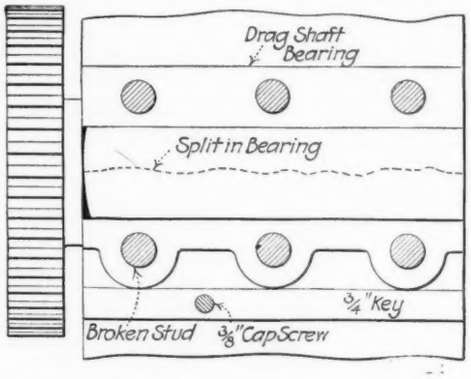
If a crucible is at hand, use brass or copper instead of lead or babbitt. The wood mold cannot be used because the temperature is too high. A mold made of a split pipe, however, will do very well for a brass hammer.

J. C. HAWKINS.

Hyattsville, Md.

Repair to Bearing

The breaking of a tooth in the drive pinion on the main shaft of a large gas engine caused the drag shaft to be forced back, shearing two studs and splitting its



KEY INSERTED TO HOLD BROKEN BEARING IN PLACE

bearing the entire length. As there was not time to wait for a new bearing from the factory, the broken one was taken out, the side squared up and the slot in the bed,

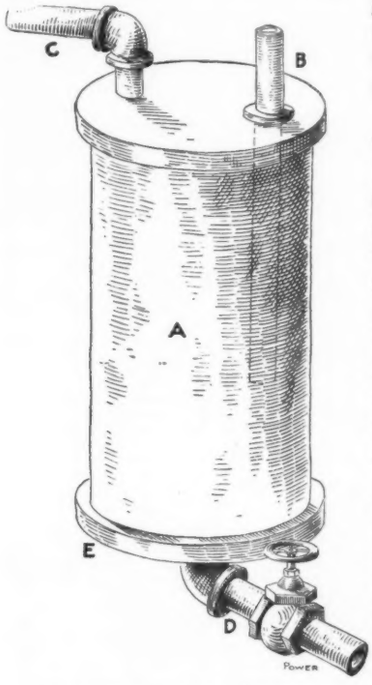
where it had been trued up for the bearing, was filed square. The bearing was then replaced and a ¾-in. key driven in the space between it and the end of the slot, forcing the two halves of the bearing securely together. This key was then secured by a ⅜-in. cap-screw. The entire operation did not take more than three hours from the time of breaking the tooth until the engine was running again.

WILLIAM VAUGHAN.

Salem, Ohio.

Gravity Boiler Skimmer

A home-made automatic gravity skimmer for boilers is shown here. It works well, taking out about half a gallon of thick, muddy mixture every hour, when river water is used.



GRAVITY BOILER SKIMMER

The body *A* is wrought-iron pipe (about 8 in. is a good size), capped or flanged at each end. Pipe *B* is connected to the surface blowoff; *C* is connected to the bottom blowoff pipe between the valve and the boiler. This construction is different from any I have seen. (The pipes *B* and *C* are taken from the top of the boiler, with one extended down inside to the water level and the other below it). The pipe *D* is the blow-off from the mud collector. The bottom *E* should be as low or lower than the boiler bottom but it may be at any convenient point.

The skimmer will prove satisfactory only when a fairly constant water level is maintained, in which case it will do as good work as any.

JAMES E. NOBLE.

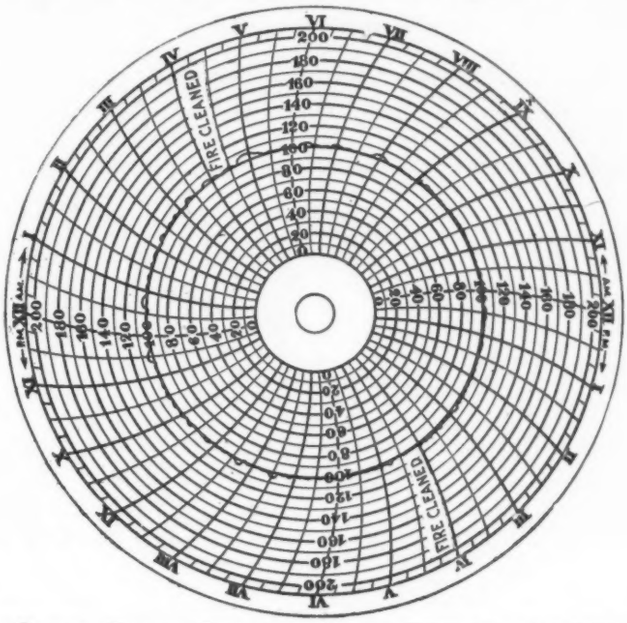
Toronto, Ont.

Steam Chart with Hand Firing

In the Mar. 31 issue, under the foregoing title, A. E. Anderson shows a good steam chart, but I want to show one made by my men under different conditions.

Instead of a battery of boilers, as Mr. Anderson has, which certainly steadies the load and gives a better chart, we have one 175-hp. return-tubular boiler in service at a time. When our load is lighting, for instance, and the 40-hp. motors for the elevator service are cutting in and out, or frequent changes of 80 hp. in the load occur, we will be carrying over 200 hp. besides using steam for other purposes, such as pumps, turkish bath, etc. This means that the boiler is doing nearer 225 hp.

We clean the fire at 4 p.m. and again at 4 a.m. The feed water ranges near 210 deg. all of the time. We burn bituminous coal, weighing it out to the day and the night man, weigh the ash made by each, meter the evaporation, the kilowatt output, etc. The evaporation averages 9 lb. of water per pound of fuel with an ash percentage of between 8 and 10.



STEAM CHART, SHOWING STEAM PRESSURE CARRIED WITH HAND FIRING

The boiler is hand fired and the firemen are careful.

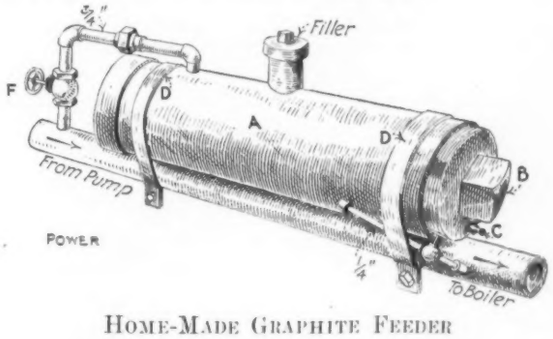
ASA P. HYDE.

Binghamton, N. Y.

Home-Made Graphite Boiler Feeder

The illustration shows a simply and easily constructed graphite feeder that I built some time ago, and which proved satisfactory in every way.

To make it, take a piece of 6-in. cast-iron pipe *A*, 24 in. long, threaded and plugged at the ends, as at *B*. In one plug insert a petcock *C*, which serves as a drain and also shows when to refill with graphite.



HOME-MADE GRAPHITE FEEDER

The pipe *A* is secured to the boiler feed-water line by two straps *D*. At the top of the tank *A* there is an opening for filling. The water in injected through the ¾-in. pipe and valve *F*, the latter regulating the flow, the graphite being forced into the feed-water line through the 1-in. pipe, which has a valve to control the amount fed.

J. A. LUCAS.

Ozone Park, L. I., N. Y.

Water Rheostats for 2200 Volts

In the issue of June 17, 1913, R. L. Daugherty described a water rheostat for 2200-volt, three-phase current, which, while undoubtedly satisfactory for that particular test, left the impression that a water rheostat can be used on 2200-volt power-plant testing provided a creek is available. As a matter of fact, a small stream of water under a few pounds pressure from an ordinary garden hose will supply all the water necessary for 200 kw. or more.

The drawing, Fig. 1, shows a 2200-volt, single-phase or three-phase water rheostat constructed from material which is always available around a power plant.

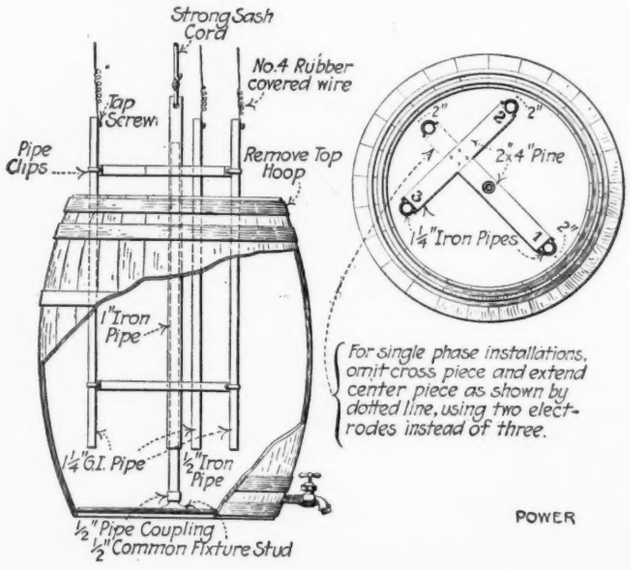


FIG. 1. SHOWING CONSTRUCTION OF RHEOSTAT

Two frames are constructed in the form of a T, to which 1¼-in. pipes are secured at the three ends, as shown. This triangle of pipes forms the electrodes, to which wires of any convenient size are attached by soldering or by means of screws. A 1-in. pipe is placed in the center of the triangle as a support and guide for the electrodes, and a ½-in. pipe is secured in the center of the bottom of any large barrel. This latter pipe fits inside of the first, so as to prevent the electrodes from swinging to the edges of the barrel. It is well to remove the top hoop, as it prevents the possibility of charring the ends of the staves. A hose bibb can be inserted near the bottom of the barrel for attaching a ¾-in. hose, or the hose can be dropped into the top of the barrel. The rheostat can be supported on blocks of wood or rest directly on the ground. Water can be allowed to overflow the top edges of the barrel or may be carried away through a pipe attached near the top.

When the barrel is filled with water the electrodes can be easily adjusted to a level position so as to equalize the load on each phase. Any desired load within the capacity of the rheostat can be obtained by adjusting the depth of emersion. The capacity of such a rheostat depends on the quality and quantity of water available for cooling purposes. The chart in Fig. 2 shows a few capacity-emersion curves for different qualities and pressures of water. The form of the load curve depends upon the quantity, hence the pressure of cooling water and the angle or slope of the curve depends on the quality of the cooling water. The lower curve is the result of using slightly brackish cooling water.

The writer has used this type of rheostat extensively on 2200 volts in various sections of the country. A

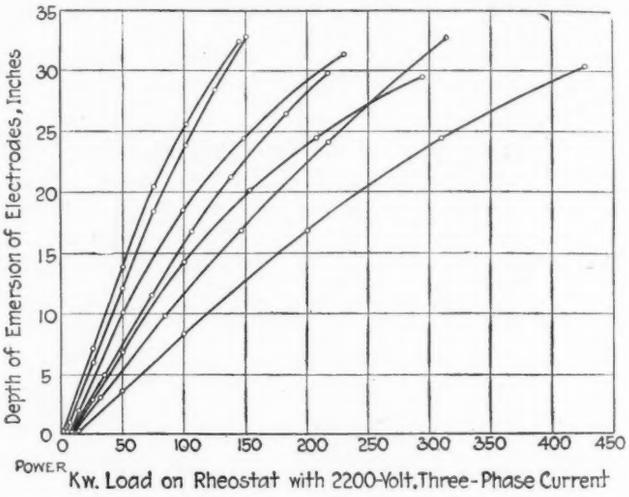


FIG. 2. CAPACITY-EMERSION CURVES

rheostat constructed with a 56-gal. oil barrel and electrodes in a triangle 13 in. on centers will have a capacity of from 50 to 400 kw. Mere contact of the electrodes with the water will produce a load of from 3 to 15 kw. The capacity can be increased by reducing the size of the triangle or increasing the size of the elec-

FIG. 3. RHEOSTAT IN SERVICE

trodes, but in no case should the electrodes be less than eight inches on centers. With a steady flow of cooling water constant load can be maintained.

P. M. ANDERSON.

Washington, D. C.

Inquiries of General Interest

Fluctuation of Governor—Can a centrifugal governor maintain uniform speed for different loads carried by the engine?

C. R.

Only approximately, as each load requires a different position of the throttle or cutoff valve, and the different positions required of the governor balls are only attained by different speeds of the engine.

Advantage of Dutch-Oven Furnace—What is the advantage of the Dutch-oven furnace?

W. J.

The principal advantage is in having a large combustion chamber and longer path for the hot gases before reaching the comparatively cool surfaces of the boiler, thus permitting of combustion at a higher temperature.

Outside Packed Pump—What is meant by an outside packed pump?

J. P.

One having a plunger piston which is packed from the outside of the cylinder by means of a gland and stuffing box, as distinguished from an ordinary piston pump in which the piston packing is inside of the pump cylinder.

Differential Plunger Pump—What are the advantages of a differential plunger pump?

R. T.

With a simple plunger or bucket pump, the discharge is intermittent, whereas with a differential plunger pump on the up-stroke twice the amount of water discharged is drawn into the lower chamber, and on the down stroke one-half of that drawn into the lower chamber is discharged. The continuous discharge permits use of a smaller discharge pipe, is less productive of shocks and prevents the accumulation of sand or sediment on the discharge valves.

Current for Three-Phase Motor—What current would be required in each phase for 10-hp., three-phase, 500-volt motor?

C. B.

A motor of the size stated would have an efficiency of about 88 per cent., so that the required input would be

$$10 \div 0.88 = 11.36 \text{ hp. or } 8474 \text{ watts.}$$

Assuming the power factor at 85 per cent., then using the formula for the power in a three-phase circuit, viz:

$$\text{Watts} = \text{amperes} \times \text{volts} \times \sqrt{3} \times \text{power factor}$$

and substituting

$$8474 = \text{amperes} \times 500 \times \sqrt{3} \times 0.85$$

or amperes = 11.5.

Vertical vs. Horizontal Water Turbines—What are the relative advantages of vertical-shaft and horizontal-shaft water turbines?

M. G.

There is practically no difference in efficiencies. A vertical shaft turbine requires less floor space and is generally preferable for low heads where it is necessary to set the turbine down near the level of the tail water. Horizontal shaft turbines are more desirable for any situation where it is practical to use them on account of greater accessibility, less bearing trouble, capability of direct connection to horizontal generators and adaptability of power transmission to horizontal shafting.

Which End of Cylinder Receives More Steam?—When there is the same percentage of clearance, the same back pressure of the exhaust and the same power developd in each end of an engine cylinder, which end receives the greater amount of steam?

O. H. D.

With the cutoff of the head end occurring at the most economical point or later in the stroke, the less piston displacement in the crank end of the cylinder due to the presence of the piston rod, would require a higher mean effective pressure for development of the same power; hence with the same initial pressure there would be a later point of cutoff and less benefit from working the steam expansively in the crank end of the cylinder and consequently more steam would be required for developing the same power.

Required Voltage—How is the electromotive force found which will force 15 amperes through a 60-cycle circuit having a resistance of 15 ohms and an inductance of 0.08 Henry?

S. C.

Solution is by the formula

$$E = I \sqrt{R^2 + (2\pi fL)^2}$$

in which

E = Electromotive force;
I = Current;
R = Ohms resistance;
f = Frequency;
L = Inductance in Henrys;
π = 3.1416.

Substituting we obtain:

$$E = 15 \sqrt{15^2 + (2 \times 3.1416 \times 60 \times 0.08)^2} = 505 \text{ volts.}$$

Mechanics Problem—If two men are to carry a weight of 250 lb. on a pole 10 ft. long, where must the weight be hung to let one man carry only 25 lb.?

P. J. M.

The other man must carry

$$250 - 25 = 225 \text{ lb.}$$

The distances from the point where the weight is suspended to the points held by each man will be inversely proportional to the two weights, and 25 being contained in 225 nine times, the distances will be 1 to 9, or the total 10. Therefore, if the weight is put 1 ft. from the man who carries 225 lb. the other man would only have to carry 25 lb., his distance being 9 ft. from the weight. Problem 26, answered in Lesson VII of the Engineers' Study Course on Elementary Mechanics, page 642 of the May 5, 1914, issue, was a similar problem.

Clearing Obstructed Water Pipes—How can incrustations or deposits in water-supply pipes be removed without using a solvent which would impair the potability of the water supply?

C. G.

For clearing large water pipes various forms of mechanical cleaners are employed which are forced through the pipes and are operated by water pressure. These loosen the scale and tubercules by the action of revolving or vibrating cutters. Service pipes 1¼ in. and less in size, which have become clogged by soft deposits or obstructed from the formation of tubercules, have been successfully cleared by forcing through them wads of manila tissue paper rolled into small crumpled balls of dry paper, which are introduced at the pipe outlet and are forced, one at a time, back into the main by means of water discharged from a hand force pump connected at the pipe outlet. When a pipe is cleared in this manner the wads introduced should be gradually increased in size, and the flow should be tested after each paper ball is forced through the pipe.

Spacing Flange Bolt Holes—What is the rule by which to set dividers to lay off the centers for any number of bolt holes in a flange? For example, how would nine holes be spaced on an 18-in. bolt circle?

W. F. L.

The finding of the exact distance between bolt holes on a flange circle is generally a matter of cut and try. We would suggest the following as the best method: Get the circumference of the bolt-hole circle by multiplying the diameter by 3.1416; divide this by the number of bolts. Space off with dividers, set to some fraction of this distance, the number of steps it is necessary to go from point to point along the circle and having determined the distance between the holes, set the dividers with a point on each center and lay off the rest of the bolt holes directly. If there is a slight error in completing the circle, divide this error by the number of holes, reset the dividers, and lay off again. For example, to space nine bolt holes in an 18-in. circle, the procedure might be as follows: The circumference of the circle will be

$$18 \times 3.1416 = 56.55.$$

This divided by 9 would equal 6.28, or very nearly 6¼ in. Setting the dividers at ¼ in., lay off this space ($6\frac{1}{4} \div \frac{1}{4} =$) 25 times along the circumference. The distance between the two ends of this arc will be the chord between the bolt holes and the dividers can be set directly at this distance and the rest of the holes laid out at once.

Engineers' Study Course

Elementary Mechanics--XX

LAST LESSON'S ANSWERS

86. If it were not for the force of gravity the distance the plate would move in T sec. would be UT ft.; but during the same time gravity acts and retards the motion of the body by an amount equal to $\frac{1}{2}\ gT^2$; therefore the total distance passed over by a body projected vertically upward may be found from the equation,

$$S = UT - \tfrac{1}{2}\ gT^2 \qquad (50)$$

where

U = the initial velocity of the body in feet per second;

T = The total time of flight in seconds.

If the value of S should work out negative it means that the body had reached its highest point and had returned to the ground before the completion of the assumed time. Furthermore, the above equation does not state whether the body is rising or falling, but this may be determined by ascertaining the time of ascent from the equation $T_1 = \frac{U}{g}$. In this problem

$$T_1 = \frac{100}{32} = 3+ \text{ sec.}$$

Hence at the end of the second second the plate is still rising, and its height from the ground is found thus:

$$S = UT - \tfrac{1}{2}gT^2 = 100 \times 2 - \tfrac{1}{2} \times 32.16 \times 2^2 = 135.7 \text{ ft.}$$

87. The density of water is the mass of a cubic foot of water, and at about 39 deg. F. is 62.4 lb. per cu.ft.

The density of coal varies, depending upon the size and kind of coal. An average value for anthracite coal is 96 lb. per cu.ft. When piled in heaps the density will average about 55 lb. per cu.ft.

The *specific gravity* of a material is its weight compared with an even volume of water. Thus the density of wrought iron is 480 lb. per cu.ft., but its specific gravity is $\frac{480}{62.4} = 7+$.

88. From equation (47) $F = M \times a$. In this case the mass is 100 lb. and the acceleration is 4 ft. per sec., hence the force F in poundals is equal to $100 \times 4 = 400$.

89. The weight of the flywheel is 10 tons, or 20,000 lb. When the wheel is suspended from the crane hook the tension in the cable is 20,000 lb. (neglecting the weight of the block, cable, etc.), but when the weight is being put in motion the tension in the cable is increased an amount equal to the force which is required to overcome the inertia and to give the desired acceleration. This force may be found from equation (49), where

$$F = \frac{W}{g} \times a$$

$$F = \frac{20{,}000}{32.16} \times 1.25 = 777.4 \text{ lb.}$$

Therefore, the total pull in the cable while the load is getting under way is equal to

$$20{,}000 + 777.4 = 20{,}777.4 \text{ lb.}$$

90. When the flywheel is coming to rest its inertia will tend to reduce the tension in the cable. The force of inertia will equal

$$\frac{20{,}000}{32.16} \times 2 = 1244 \text{ lb.}$$

and the tension in the cable is equal to

$$20{,}000 - 1244 = 18{,}756 \text{ lb.}$$

WORK

A force is said to do *work* when it overcomes a resistance and causes an object to move in any given direction, or, as commonly expressed, *work is the overcoming of a resistance through a definite distance*. A horse moving a loaded van does work; the steam acting on the piston of an engine, by overcoming an external resistance, does work. An engineer may tug at the flywheel to move his engine off dead center, but no work will be done unless he has sufficient strength to turn the wheel. Hence the idea of work involves two fundamental notions; first, that of a resistance, and second, the overcoming of this resistance so that motion results. Moreover, the force exerted must be measured in the direction in which the resistance moves. There can be no work done on a body unless the body is put in motion.

The unit of work is the foot-pound. Thus, if a weight of one pound is raised through a vertical distance of one foot, the work done is one foot-pound; if the weight was 500 lb. and the distance 5 ft., the work done would equal 500 × 5 or 2500 ft.-lb. *The element of time does not enter into the idea of work;* thus the work done in raising the 500 lb. through the vertical distance of 5 ft. is 2500 ft.-lb., irrespective of whether it takes one minute or one hour to raise the weight.

A general equation for work may be expressed as follows:

Let W = the work done in foot-pounds,

F = the resistance overcome in pounds,

S = the space passed over by the resistance in feet,

then, since work = force × distance,

$$W = F \times S \qquad (51)$$

A careful distinction must be made between the terms resistance overcome and the weight of the body moved.

Where bodies are raised in a vertical direction there the resistance overcome and the weight are equal to each other. Take, for example, a clam-shell bucket used for raising the coal from the barges to the bunkers of a power house. Here the resistance overcome by the hoisting engine is the weight of the bucket and the coal it contains. When this coal is placed in the distributing cars over the bunkers the force exerted by a cable to move a car is not equal to the weight of the car and its load, but to the force of friction between the car and the track. This force of friction is decidedly less than the weight of the car. When objects are moved along

horizontal surfaces, the resistance overcome seldom equals the weight of the object moved. Hence in figuring the work done by a force in moving an object through a given distance the essential thing is to determine the resistance overcome and then the work may be readily determined.

Example—A clam-shell bucket loaded with coal weighs three tons. How many foot-pounds of work will it require to raise the bucket a vertical distance of 200 ft.?

Here the resistance to be overcome is 6000 pounds and the distance is 200 ft., hence the work done is equal to

$$6000 \times 200 = 1{,}200{,}000 \ ft.\text{-}lb.$$

Example—Find the work done by a fireman in moving a coal truck weighing 1000 lb. across the floor of a boiler room 100 ft. wide, assuming the friction between the truck and floor as 50 lb. per ton.

In this problem the resistance overcome is not the weight of the car, but the friction between the car and the floor, which is equal to

$$\tfrac{1}{2} \times 50 \ or \ 25 \ lb.$$

since the car weighs one-half of a ton. The work done by the fireman is then equal to

$$25 \times 100 = 2500 \ ft.\text{-}lb.$$

Power

Power is the time rate of doing work or is the capacity of an agent for doing work at a uniform rate. The more work an agent can do in a unit of time the greater will be its power. The commonly accepted unit of power is the horsepower, which is the equivalent of 33,000 ft.-lb. of work being done every minute, or 550 ft.-lb. every second. This unit was named and adopted by Watt, as he figured that an ordinary dray horse was capable of doing 33,000 ft.-lb. of work per minute. Throughout this work the term horsepower will be expressed by the symbol *hp.*

Example—In the case of the clam-shell bucket the work done was 1,200,000 ft.-lb. If the load had been raised in one minute, then the horsepower required would equal

$$\frac{1{,}200{,}000}{33{,}000} = 36.3+ \ hp.$$

If the work had required 3 min. the hp. would have been only 12.1, so that the greater the time the less will be the power required to do a definite amount of work.

Let T = the time required to do a certain amount of work,
F = the resistance overcome in pounds,
S = the space passed over by the resistance in feet,
$hp.$ = the horsepower required, then

$$hp. = \frac{F \times S}{T \times 33{,}000} \qquad (52)$$

Efficiency

A machine is a device for the performance of useful work. Generally the machine will be supplied with power from some external source, and experience teaches that it is impossible to convert all the power supplied into useful work. There are numerous losses in the machine itself, such as the friction in the bearings, the loss in gears and belts, friction between sliding parts, and many others too numerous to mention. The power supplied to the machine (commonly called the input) must equal the losses in the machine plus the power developed by the machine (commonly called the output).

The *efficiency* of a machine is expressed in terms of the per cent. of the input converted into useful work or put in the form of an equation:

$$efficiency = \frac{output}{input} \qquad (53)$$

Example—Assume the efficiency between the engine and the bucket (in previous example) to be 60 per cent. What horsepower engine would be required to raise the bucket?

The power required at the load was found to be 36.3 hp. As this, (the output) represents only 60 per cent. of the input, it must be evident that the horsepower of the engine must be equal to the output divided by the efficiency, or

$$\frac{36.3}{0.60} = 60 \ hp.$$

Study Questions

91. The average unbalanced steam pressure on the piston of an engine is 35 lb. per sq.in. If the diameter

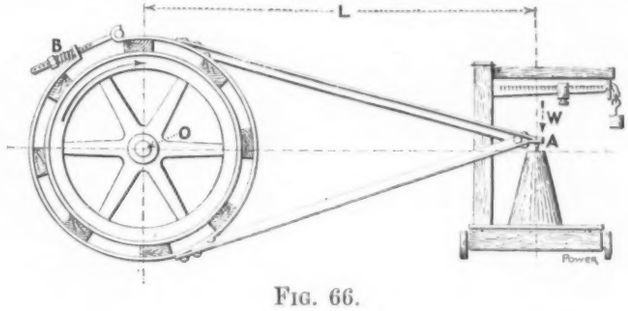


Fig. 66.

of the piston is 9 in. and the stroke of the engine is 12 in., find the work done by the steam in one revolution of the engine. (Assume the engine to be double acting.)

92. In problem 91, if the engine makes 250 r.p.m., find the horsepower developed in the engine cylinder.

93. Fig. 66 shows a common form of prony brake used in the testing of engines. During a test of the engine in problem 92 the length of the brake arm L was 5 ft., the net load on the brake was 120 lb. Find the horsepower developed at the brake.

94. From the results of problems 92 and 93 find the mechanical efficiency of the engine.

95. Explain what becomes of the power developed at the brake. Is it possible for the brake-horsepower to be greater than the power developed in the engine cylinder?

Cost per Square Foot for Building Upkeep—The cost per square foot of rentable area for the upkeep of skyscraper office buildings says "Building Management," no doubt varies greatly in New York. A table recently prepared by C. T. Coley, the operating manager of the New Equitable, has inspired Vice-President Mortimer of the U. S. Realty & Improvement Co. to prepare a table showing average costs per square foot of rentable area in some of the first-class buildings of New York, as he found them, covering a period of five years:

Engine-room labor, supplies, etc	$0.052
Coal and ash removal	0.067
Elevator labor, supplies and repairs	0.050
Janitor's labor and supplies	0.094
Electrician's labor and supplies	0.010
Supervision	0.016
Repairs to building and plant	0.032
Tenant changes and alterations	0.040
Building supplies, gas and sundries	0.008
Insurance	0.011
Water	0.009
Total	$0.389

T. Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—A colliery power plant is inspected, in which, by the installation of a low-pressure steam turbine, surface condenser and cooling tower, the capacity of the plant was practically doubled. The saving in coal amounted to about $400 per month, although the electrical load increased about 40 per cent. over former conditions.

Early the next morning Hunter and I made a start to visit the workings of the Penn Mary Coal Co., at Heilwood, Penn. This necessitated a ride by train of some miles, which gave us opportunity to talk shop. Hunter, as usual, made for the smoking car and lighting an apology for a cigar, I never determined its brand, settled himself as comfortably as he could.

Evidently his thoughts were running in the same channel as my own, for he presently knocked the black ashes from the end of the stuff he was smoking and said, "The mine operator has got his work cut out for him when he begins to consider either building a central power plant or purchasing the electrical energy from a central station to replace the old steam plants.

"The ghost of cost looms up at every turn. In the first place, he believes that power has been produced at a reasonable cost; whether it has or not, is another question. It is true the fuel is cheap and the apparatus in the old steam plants is of the most simple type, but he cannot get over wondering what it will cost under the new order of things if the change is made. In most cases the private central station is constructed."

"I should think that purchasing energy from a central station would remove the bother of operating a power plant, and then all that would have to be done would be to ship the coal and collect the cash."

"That sounds good, but there is no reason that I can see, why the coal producer should not build and operate his own plant, and produce an electrical output as cheaply, if not cheaper than it can be purchased.

"I believe I told you a few days ago that the general run of colliery steam boilers were a source of great loss, let alone the condition in which the various engines and pumps are run. Some operators have awakened to the fact that where fuel was a few years ago worth about 30c. a ton, it is now worth about 80c. a ton."

At this point in Hunter's discourse, the train pulled into the station and we were soon climbing the steep hill, and it was steep. A barnstorming company playing in "The Old Homestead" made the climb at the same time, but although they had doubtless had more practice, we outdistanced them to the hotel. After something to eat, we hunted up the superintendent of the colliery and obtained permission to look over the power plant, down at the foot of the hill.

The interesting feature about this installation was doubling the output without increasing the coal consumption. This was done by installing a low-pressure steam turbine, which uses the exhaust steam from the reciprocating engines which had before that exhausted to the atmosphere.

"You see," said Hunter, "in the colliery, because of the steep grades, in some instances 5, in others 16 per cent., motors are assisted by electric hoists. The motor is used to unwind the cable and pull the empty cars into the mine where the slope in the grade decreases; on the outward trip, the motor pushes the trip, both cable and motor working together.

"Before the changes were made the generating equipment consisted of four 18x22-in. side-crank engines, each directly connected to a 200-kw., 250-volt direct-current generator, at 225 r.p.m."

"I thought you said the other day that alternating current was generated at the power plant and changed to direct current at each mine."

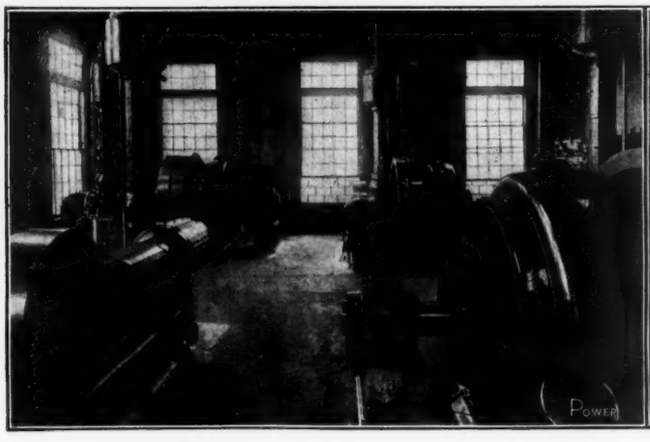


Fig. 1. Old Engine Room and Reciprocating Engines

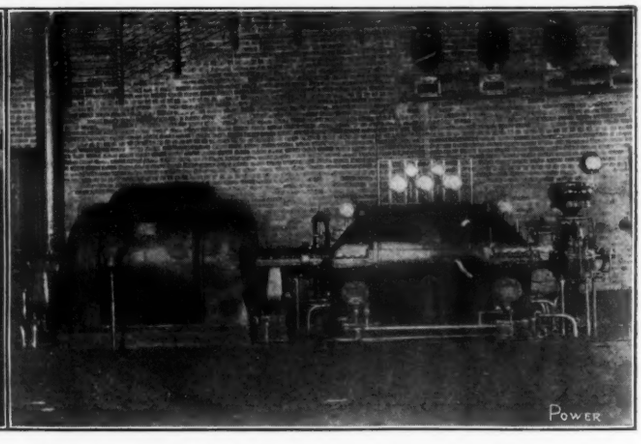


Fig. 2. Low-Pressure Exhaust Steam-Turbine Unit

"So I did, but when the original equipment was installed, direct current was the best to use, as the workings were close to the power house. When these workings got further away from the power house, it became as plain as the nose on your face that some provision must be made to transmit the electrical energy to the distant parts of the mine. Therefore the turbine and alternating generator were installed."

Arriving at the plant, we entered the old engine room,

Fig. 1, in which the reciprocating engines were housed. At the end of this room is the turbine room, where a 750-kw. exhaust-steam turbine was installed, Fig. 2. The generator end produced energy at 2400 volts, three-phase, 60-cycle current at 3600 r.p.m.

Out in the boiler room were the four original water-tube boilers and two new water-tube boilers, Fig. 3, each of 300-hp. rating, and carrying 125-lb. steam pressure. The brick stack was 125 ft. high.

In the turbine room there was a 25-hp., 250-volt balancing set.

"When it became evident that more power was wanted," resumed Hunter, as we stood looking at the turbine unit, "it became a question of either having one power plant or several distributed at the mines.

"We have already said the latter method is not economical and a study of the situation showed this to be the case in this instance. Then the matter of deciding how to increase the output of the plant with the least outlay had to be settled. The result was that the direct-current units supply the works near the power plant with direct current and the exhaust-steam turbine and alternating-current generator supply high voltage energy for the distant workings.

"The reciprocating units exhaust into a common exhaust line which runs to the turbine, and also has a live-steam connection so that the turbine can be run in case all of the engines are shut down, and there is no exhaust steam for the turbine to use."

"How can a turbine run on exhaust steam and double the output of the station?"

"It does seem a little off color at first thought, but it's as plain as daylight after you once get the hang of the thing. You see those engines were exhausting to the atmosphere at, say, 2-lb. back pressure on every square inch of the piston area, or practically 17 lb. absolute pressure. Now all of that pressure that can be eliminated will tend to increase the horsepower output of the engine.

"When the turbine was connected to the exhaust pipe of the engines and was piped to a condenser on the other side, the steam from the engines went to the condenser just the same as if the piping had been direct, instead of through a turbine. The back pressure was reduced in proportion to the vacuum carried which if 28 in. would reduce the absolute pressure in the turbine exhaust pipe pipe to less than one pound, or 0.946 lb. per sq.in. That makes a difference in the absolute exhaust pressure of 16.054 lb. per sq.in. over what the engines did exhaust at and the pressure at what the turbine exhausts.

"It is the exhaust steam from the reciprocating engines rushing through the turbine to the condenser (Fig. 4) that governs the additional power.

"Of course the condenser has to be supplied with sufficient cooling water, which in this case is not plentiful, and for that reason a cooling tower is used to reduce the temperature of the water after passing through the condenser."

"That's funny, a cooling tower at a mine where all kinds of water can be had for the pumping. Why don't they pump the mine water to the condenser and kill two birds with one stone?"

"You forget," answered Hunter, "that mine water is mighty hard on condensers, and that by using a cooling tower, the water can be used over and over in practically a pure state. It was found, at this mine, that using a cooling tower is more economical than the method you suggest, or even than obtaining the necessary water by pumping from a deep well."

"It takes power to drive the fans, doesn't it?" I next asked, "and that detracts from the saving made by using the turbine. It seems to me that with the cost of the turbine, condenser and cooling tower the gain made by using exhaust steam would be offset by the additional cost of the new apparatus."

"The cost would amount to considerable. On the condenser, there would be the circulating and air pumps, which are operated by a steam turbine, the exhaust of which is used to heat the feed water going to the boilers. Then there would be the 18-hp. motor required to run the air fan at the cooling tower, which de-

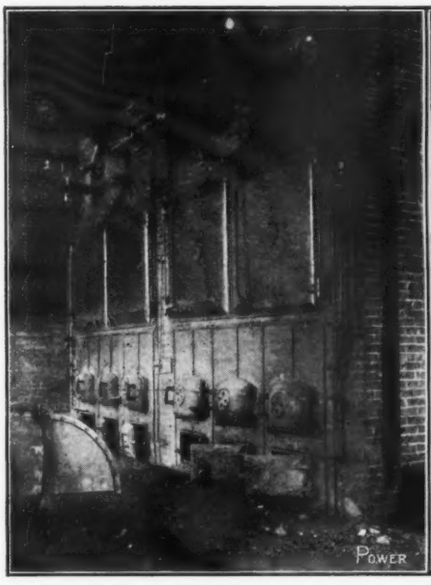


FIG. 3. THE TWO NEW 300-HP. WATER-TUBE BOILERS

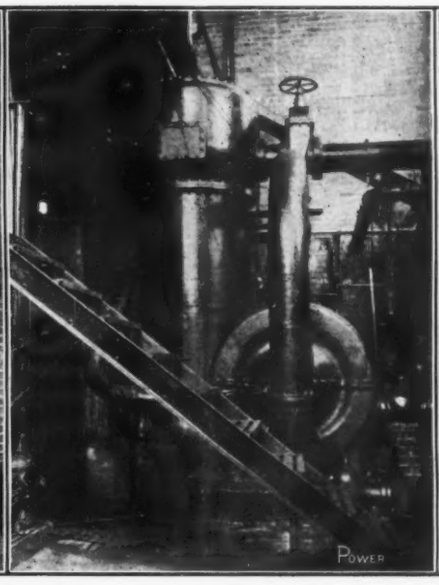


FIG. 4. LEBLANC CONDENSER SERVING EXHAUST STEAM TURBINE

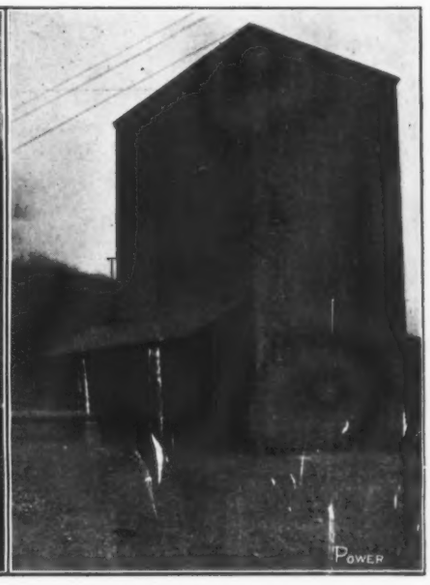


FIG. 5. EXTERIOR VIEW OF AIR-COOLING TOWER

livers the air to the water as it trickles down through the tower. In winter the problem is to prevent ice forming at the fan intake, and so each fan is surrounded by a ring of pipe perforated with small holes through which steam escapes when there is a tendency for ice to form.

"These all take from the economy of the power plant, but for all that, I understand over $400 a month has been saved in the cost of coal since the turbine outfit has been running, over the cost of operating with the old conditions for similar months, although the electrical load has increased something like 40 per cent."

"Of course the alternating current is sent to the substations and there converted to direct current for mine use," I said as I put my camera in its case.

"Sure! There are two substations, each containing a 300-kw., 250-volt generator, driven by a 450-hp. synchronous motor. This electrical energy is used for lighting, electric haulage, electric pumping and ventilating fan motors."

As it was getting along toward train time, and not caring to take in "The Old Homestead" show, we said "So-long" to the boys at the plant and were soon rumbling on our way.

Installing and Starting Centrifugal Pumps

By William Salt

SYNOPSIS—What to do and what may lead to trouble in erecting and starting centrifugal pumping outfits.

Many visits to correct supposed pump troubles, which later proved to be faults of installation or operation, suggest the following as being of interest to users of centrifugal pumps.

Unpacking

The centrifugal pump, whether arranged for motor, turbine or belt drive, is usually mounted on the bedplate with the driver, making a complete unit. Therefore, when unpacking, guard the apparatus against shocks or blows that might injure the parts. Use a rope or a chain if possible under the bedplate when lifting the complete machine, and keep the suction and discharge openings blanked until ready for the pipe connections to insure a clean pump when starting.

Foundations

The foundation should be solid enough to prevent the distortion of the bed or base plate. Masonry or concrete foundations are preferred to wooden supports. Foundation bolts are not necessary with a solid foundation when motor or turbine drive is used, but they should be used with the belt or engine drive.

Erecting the Outfit

The driving and pump shafts should be level and the bearings properly lined with each other. When separate shafts are used the couplings should be disconnected by removing the bolts, and the final alignment of the machine carefully checked by using a straight-edge or scale on the outer diameter; a thickness gage between the bases will show if the couplings are true with each other.

Piping

Care must be taken in making up the piping at the pump to prevent strains in the case or bedplate. After the piping is completely made up on the system, the joints at the suction and discharge should be loosened to see that the faces are parallel and that the piping lines up properly. Excessive piping strains will distort the case and throw the shaft out of alignment. When handling hot liquid, care must be exercised in planning the piping system to prevent strains due to expansion.

When using a siphon or injector for priming, it is necessary to have a valve in the discharge piping. This valve is usually at some convenient point near the pump, the minimum distance being two to three feet, to give the best results in starting. The connection to the siphon should be made at the top of the pump case and at the highest point in the discharge pipe between the check or stop valve and the pump.

With a foot valve on the suction, the pump and piping should be primed with water from the general supply system. An air vent valve must be put on top of the case at the highest point in the discharge pipe below the check or stop valve. The suction pipe must have a gradual drop from the pump to the intake to prevent air pockets, which would give trouble in starting and during the operation of the pump.

Sealing the Glands

Packing boxes are often fitted with a spacer between the packing directly under the pipe tap holes in the upper half of the case or with channels leading to the discharge chamber of the pump case. When arranged for outside pipe connection the pipe should connect with the water-supply system beyond the discharge valve of the pump to furnish sealing water when starting and during operation. If the pump is handling dirty or gritty water that would cut the shaft, clean or filtered water should be fed to this point if possible. If the packing boxes are not water-sealed, greater care must be had in fitting and adjusting the packing.

Starting the Pump

See that the machine is thoroughly cleaned; fill the oil reservoirs with a good quality of mineral oil, being sure that the oil level is high enough to insure the rings giving the right supply of oil to the bearings. When the pump is attached to a motor, or is belt driven, that pump must have the proper rotation; this is indicated usually by an arrow on the casing, or is given on the instruction card. If operated in the opposite direction the pump will give trouble, as most of them are designed for one direction only. With a motor-driven pump the coupling bolts should be taken out before testing the motor for direction of rotation.

When correct rotation has been determined, the pump is ready to be coupled to a driver and must be primed so that the case will be thoroughly filled with water before testing out for its service condition.

Michigan N. A. S. E. State Convention

On July 15 to 17 Michigan's annual state convention was held at Muskegon. Arbeiter Hall was headquarters for the engineers and exhibitors. The invocation, by the Rev. A. Hadden, was followed by the address of welcome, delivered by Mayor John H. Moore. F. W. Raven, national secretary, responded and John McGrath, past national president, gave a general talk on the purposes of the organization. In the afternoon the engineers enjoyed a boat ride on Muskegon Lake and inspected the plant of the Central Paper Co.

The feature of the Thursday morning session was an address by F. E. McKee, general manager of the Shaw Electric Crane Works, on the subject, "Industrial Education." Mr. McKee favors the alternate weekly system, in which the rudiments of molding, printing, turning, etc., are obtained in the school and the actual experience in different shops where the student is sent to apply his knowledge. The speaker also discussed the safety of employees. Owners of factories were just as anxious for the safety of their employees as they were themselves. He favored laws for safety, just laws which would not eliminate features tending toward economy in production. At 2 P. M. the engineers left by trolley for Recreation Park. Boat rides were taken on Lake Harbor, but most of the conventioners attended the ball game between the engineers and exhibitors. The result was a disastrous rout for the latter, the score being 20 to 6.

On Friday Jackson was chosen as the convention city for 1915. The following officers were elected: President, John Andrews, Pontiac; vice-president, Fred Tech, Flint; secretary, E. C. Smith, Kalamazoo; treasurer, Henry Badley, Owosso; conductor, George Maloney, Jackson; door-keeper, Edward Rose, Detroit; state deputy, W. H. Moore, Detroit; trustee for one year, C. H. Sisson, Muskegon; for two years, William Mauthe, Muskegon; for three years, Charles White, Detroit.

In the afternoon there were special cars to Lake Michigan and later to Recreation Park, where a fish supper was served, followed by dancing.

THE EXHIBITORS

Below are given a list of the exhibitors:

American Steam Gauge & Valve Co.
The V. D. Anderson Co.
Arrow Boiler Compound Co.
Bowers Rubber Works
Buckeye Chemical Co.
Craig-Millard Co.
Crandall Packing Co.
Dearborn Chemical Co.
The Garlock Packing Co.
Grand Rapids Supply Co.
Greene, Tweed & Co
Griscom-Russell Co.
Hawk-Eye Compound Co.
Home Rubber Co.
J. J. Howdin Co.
Jenkins Bros.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Lagonda Mfg. Co.
The Lunkenheimer Co.
H. Mueller Co.
"National Engineer"
The Perolin Co. of America
William Powell Co.
"Power"
Standard Oil Co.
Towner Hardware Co.
White Star Refining Co.

New York Engineers' Fight on the Central Station

Feeling it necessary to combat the aggressiveness of the local electric service company in attempting to suppress isolated electric plants, the New York members of the National Association of Stationary Engineers and the International Union of Steam Engineers, as well as a number of local engineers' societies, have formed "The Joint Committee of Greater New York Engineers." The investigations so far undertaken, according to a circular recently published, have developed the following:

PROCEEDINGS BEFORE THE PUBLIC SERVICE COMMISSION

In Case 1395, brought by the Joint Committee as attorneys in fact of over 200 small consumers against the New York Edison Co., the schedule of rates established by the company July 1, 1911, was attacked as long ago as September, 1911. The following facts were proved:

a. That the Public Service Commission affords a tribunal before which the customers of public service corporations can force the corporation to make public under oath information necessary to be known by the customer in order to deal intelligently with the corporation and which, without the machinery of the Public Service Commission's law, the customers could not secure in any accurate form.

b. That the Public Service Commission will undertake for consumers and the community generally a public investigation into the rates and contract requirements of public service corporations with a view to correcting discriminatory and other illegal practices.

c. That the New York Edison Co., under its existing rates, is unable to compete with an efficient private plant in supplying electric current, and can prevent the installation of private plants in large buildings only:

1. By resorting to rates and forms of contracts which have not been made public and which therefore are illegal and in violation of the orders of the Commission; or

2. By compelling the making of an uneconomic contract through the exercise of ulterior influences; or

3. By making contracts through subsidaries for the supply of light, heat and power on a flat annual basis; or

4. By establishing a minimum wholesale rate of 2 cents per kilowatt hour for large consumers, which rate would be far below cost.

d. That the attempts to give unpublished low rates to Gimbel Brothers and the Bowling Green Building through the subterfuge of paying exorbitant rent for underground space in the customer's premises, are illegal and void.

e. That published contracts through the non-enforcement of which discrimination was attempted in favor of big contractors to induce them to use electricity as the sole source of power, will be strictly enforced and the attempted discrimination thus prevented.

f. That subsidiary corporations making contracts for the supply of light, heat and power for a flat annual price will be regulated as to rates and contract forms in the same manner as other public service corporations.

g. That the New York Edison Co. is controlled through stock ownership by the Consolidated Gas Co., which is seeking to perfect a monopoly of the supply of gas and electricity throughout Greater New York and Westchester County, and that the effort to make electricity generated in central Manhattan stations the sole source of energy in that territory is but a part of the process in the formation of an electric power monopoly throughout the nation to which warning attention has already been called by the United States Commissioner of Corporations.

AQUEDUCT FRANCHISE APPLICATION

The Joint Committee have opposed the application of the New York Edison Co. and its three affiliated companies to the Board of Estimate and Apportionment of the City of New York for a franchise or right of way over all the lands acquired by the City for aqueduct purposes. A written argument in opposition has been filed with every member of the said Board and with the Secretary thereof and the Chief of the Bureau of Franchises. But for this opposition, apparently, the application would not have been opposed. Attention has been called to the following facts among others:

a. That the application is a part of the same policy above referred to, by which the Consolidated Gas Co. seeks to perfect a monopoly of the electrical business in this City and Westchester County.

b. That even if the City of New York in its four aqueduct lines through Westchester County has rights of way which can be used for transmitting electric current to be sold off the rights of way for general commercial use, such rights of way are of such tremendous value that they should be retained under public control and not allenated to private interests for any length of time or on any terms.

c. That if, however, such rights of way are to be alienated to the New York Edison Co., the City should receive every year as compensation for the priceless privileges granted, a large share of the benefits taken by stockholders and others out of the electric earnings of that company (in 1912 $12,890,041.83). In this way the oppressed taxpayer will receive substantial relief.

New York Steam Co. Ordered to Replace Mains

Claiming that the high-pressure mains of the New York Steam Co. are a source of damage to the block pavements, sewers, water mains and the waterproofing of the subway, the Public Service Commission has ordered the company to replace its 10½ miles of old brick trench construction with modern tile construction. A period of five years is allowed for the completion of the work, during which time not less than 12,000 ft. must be replaced each year. The cost of the replacement is estimated at about a million dollars.

The original mains were laid in a trench with brick walls 8 in. thick, the pipe being supported on iron saddles placed on brick piers. The pipe was surrounded by mineral wool and planks covered with tarred paper were placed over the trench. Trouble was experienced with water leaking in and flooding the mains, so about five years ago the plan was adopted of making a continuous drainage under the trench. The latest trenches put in by the company are of 9-in. hollow tile.

The proceedings were instituted on the motion of the commission after its engineer of substructure had made a careful study of the conditions and reported that it is a common occurrence to find the earth for some feet outside the brick walls of the steam mains filled with steam which escapes when the earth is disturbed. Temperature measurements at these points had shown from 85 to 190 degrees in winter. The leather washers in water hydrants were found burned so that the water discharged from some of the high-pressure hydrants hot enough to give off steam. Moreover, the unsatisfactory condition of the wood-block pavements in many instances was traceable to this cause, and was responsible for excessive maintenance cost. He further found that at every street intersection the waterproofing of the Broadway subway has been damaged by heat from the steam mains the asphalt having practically disappeared and the fabric dried up and cracked.

This testimony was corroborated by inspectors from the Department of Water Supply, Gas and Electricity and the Department of Public Works, who added that the temperature in the manholes adjacent to the steam mains was often such

as to render it impossible for men to work in them. A representative of the New York Edison Co. also testified as to cables having been injured and their capacity reduced because of the high temperatures from the steam mains.

The business of the New York Steam Co. dates back to 1881 when it was formed with an authorized capital of $7,500,000 to take over the franchise of an earlier company which, however, had done no operating. In 1885 its downtown plant, station B, was built in the block bounded by Cortland, Dey, Greenwich and Washington Sts. This has a rated boiler capacity of 15,800 hp., and serves 29,559 lin.ft. of mains at a boiler pressure of 95 lb., which drops to 70 lb. at points farthest from the station. The uptown district is served by station J, built in 1897 at the foot of East 59th St. An extension was added to this plant in 1908, making its total rated boiler capacity 16,500 hp. From this source 37,561 lin.ft. of mains is supplied at a boiler pressure of 55 lb., dropping to 40 lb. at the farthest points.

In all there is about 12.7 miles of mains served by the New York Steam Co., the steam in the downtown district serving 456 customers and being about equally divided between heat and power. That in the uptown district serves 625 customers, and is used almost exclusively for heating. Both a flat rate and meters are employed, the maximum rate being $2 per thousand pounds and the minimum 47c. In the uptown district where a large number of customers are charged a flat rate, the charge from Oct. 1 to June 1 is $3.50 per 1000 cu.ft. contents of the building, based on outside dimensions.

In addition to the heating plants the New York Steam Co. owns three ice plants, the "Blue Star" adjacent to station B, the "White Star" at 525 East 18th St., and the "Red Star" at 514 East 116th St. In the first of these the water from the ammonia condensers is used for steam generation.

The hearings before the Public Service Commission have established the ownership and control of the New York Steam Co., about which there has long been much speculation in the mind of the public. It appears that about two thirds of the stock is held by the Andrews Institute for Girls, a charitable institution near Cleveland, Ohio. The president of the company, G. C. St. John, owns another large block and the remainder is held by about 130 small stockholders. It is said never to have paid any dividends, and the last sale of stock reported was at the rate of $1.50 a share.

BUSINESS ITEMS

The Vilter Mfg. Co., Milwaukee, Wis., has removed its Chicago District office from 802 to 731 Monadnock Block. C. J. Heinzelman will continue as district manager.

The Sullivan Machinery Co., Peoples Gas Building, Chicago, Ill., has established a new office at Juneau, Alaska in the New Brunswick Building. Burt B. Brewster for several years past associated with the St. Louis, Mo., office has been appointed manager.

The United States Government has recently placed orders for Mietz & Weiss oil engines for the following sizes: Seven 45-hp. compressor units, two 18-hp., one 7-hp., two 12-hp., and one 150-hp. M. & W. direct reversible marine engine. These engines are built by August Mietz, 128-138 Mott St., New York.

The Wiener Machinery Co., 50 Church St., New York, is sending to power-plant men interested in locomobiles, a copy of their splendid catalog fully describing the Lanz superheated steam locomobiles, portable and semiportable. It is a large, 110-page catalog, with handsome embossed cover, and contains many fine halftone illustrations. A request brings a copy.

Here's an interesting letter which the Penberthy Injector Co., Detroit, Mich., received the other day. "—My injector has played out. It has given 18 years of service and it was a Penberthy and I want another one. The one I have is size DD. In winter we carry 90 lb. steam pressure and in summer 20 lb. One hundred horsepower return tubular boiler and a water pressure of 45 lb., would the non-lifting automatic injector be all right? I think it would and could I get it with 1¼-in. connections? Yours truly, (Signed) E. G. Stewart, Fleming Street, Coraopolis, Penn.

NEW EQUIPMENT

ATLANTIC COAST STATES

The power plant at Pawtucket, R. I., of the Blackstone Valley Gas & Electric Co. was damaged by lightning recently. Loss, $30,000.

The Mercer County Light, Heat & Power Co., Greenville, Penn., will build a new power plant, to be located near the south end of the Bessemer Bridge over the Little Shenango River.

The Reading Coal & Iron Co. contemplates the construction of a high tension power house at Pottsville, Penn.

According to press reports, the City Council of Ocean City, Md., is considering the installation of a municipal electric-light plant to furnish electricity for a three mile lighting system on the board walk.

SOUTHERN STATES

Plans are being prepared by the Logan Electric Co. for the construction of a new power plant at Logan, W. Va. C. W. Poling, Logan, is Mgr. and F. R. Weller, Hibbs Bldg., Washington, D. C., is Engr-in-Charge.

The Purified Petroleum Products Co., Louisville Trust Bldg., Louisville, Ky., is in the market for a 20 hp. motor.

The Progress Laundry Co., Louisville, Ky., will purchase eight or ten motors ranging in size from 5 to 10 hp. M. A. Myers, Inter-Southern Bldg., is in charge.

CENTRAL STATES

The citizens of DeGraff, Ohio, have voted bonds for $7500 for the improvement and extension of the municipal electric-light plant. J. T. Scott is Supt.

Bids will be received by Ernest Von Bargen, Pur. Agt., Cincinnati, Ohio, until noon, Aug. 5, for furnishing and installing new boilers in the City Hall.

The Westinghouse, Church Kerr Co., 37 Wall St., New York, N. Y., has prepared plans for the construction of an electric-light plant for the Mahoning County Light Co., Youngstown, Ohio. Estimated cost, $1,000,000.

The Chief Engineer of the City Hospital of Indianapolis, Ind., has petitioned the Board of Health to make improvements and extensions to the power plant of the hospital. Estimated cost, $17,000.

The Utility Power Co. will install a power plant in its new factory at Detroit, Mich. Preston, Brown & Walker, Dime Bank Bldg., Detroit, are Archs.

An expenditure of $25,000 is contemplated by the Bloomington & Normal Ry. & Light Co., Bloomington, Ill., for improving its power plant. M. G. Linn, Bloomington, is Gen. Supt.

The City Council of White Hall, Ill., is considering the question of installing a municipal electric-light plant.

WEST OF THE MISSISSIPPI

Bids will be received by L. D. Burgess, City Clk., until 1.30 p.m., Aug. 14, for the construction of a municipal electric-light plant at Larned, Kan.

The citizens of Kansas City, Kan., will vote Aug. 25 on the proposition to issue bonds for $650,000 for the improvement and extension of the municipal electric-light plant and water system. G. B. Little is City Clk.

The Iowa Ry. & Light Co., Cedar Rapids, Iowa, contemplates the construction of a new power plant at Iowa Falls, Iowa. Robert S. Cook, Cedar Rapids, is Pur. Agt.

Bonds for $7000 have been voted for the construction of a municipal electric-light plant at Billings, Okla.

CANADA

The Hydro-Electric Commission contemplates the installation of some new equipment in the power station at London, Ont. H. J. Glaubits is Mgr.

The City Council, Regina, Sask., will build a new power plant and extend its distributing system at a total cost of about $380,000. A. E. Chivers is Clk.

The ratepayers of Saskatoon, Sask., have approved a by-law appropriating $15,000 for the purchase of a site for the construction of a new power plant.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance. **Positions Open,** (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books) and **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

A MAN who can take charge, make repairs and adjustments on tandem gas engines wanted; all day work of six days per week; state experience and salary. P. 300, Power.

SALES MANAGER for New York territory wanted by steam turbine manufacturer; only first-class experienced salesmen need apply; to obtain consideration state fully in reply to this advertisement just what your experience has been. P. 296, Power.

MAN wanted to take charge of all maintenance work of a manufacturing concern employing about 300 hands; experience should be along the lines of power-station work, millwright work, piping work, erection of buildings, together with some experience as draftsman and in general office routine; state in your answer, age, nationality, salary and full particulars about experience and former positions within the last five years; factory is located in town of about 20,000 souls in New Jersey, one hour out of New York City. P. 299, Power.